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Source Characterization and Control Technology Assessment of Methylene Chloride Emissions from Eastman Kodak Company, Rochester, NY

Alliance Technologies Corp., Chapel Hill, NC

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16. ABSTRACT The report gives results of an assessment of potential control technologies for methylene chloride (also known as dichloromethane or DCM) emission sources at Eastman Kodak Company's Kodak Park facility in Rochester, NY. DCM is a solvent used by Kodak in the manufacture of cellulose triacetate film support. Work has involved: 1) a plant visit where major DCM emission sources were inspected, and 2) evaluation of current and potential control technologies for the DCM emission sources. The report contains information gathered during the plant visit to the Kodak Park facility. Included are emission estimates determined by Kodak of all emission points greater than 8000 lb (3600 kg)/yr DCM, as well as a description of each point observed during the visit. Also included are results of an evaluation of control technologies that might be applied to the major emission sources. A cost analysis of different add-on control devices is provided for four of the uncontrolled emission points.

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Pollution	Pollution Control	13B
Chloromethanes	Stationary Sources	07C
Solvents	Methylene Chloride	11K
Cellulose Acetate	Cellulose Triacetate	11I
Emission		14G
Photographic Film		14E

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SOURCE CHARACTERIZATION AND CONTROL TECHNOLOGY ASSESSMENT OF METHYLENE CHLORIDE EMISSIONS FROM EASTMAN KODAK COMPANY, ROCHESTER, NY

by

Stephen A. Walata III
and
Richard M. Rehm
Alliance Technologies Corporation
Chapel Hill, NC 27514

EPA Contract No. 68-02-4396
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Project Officer

Charles H. Darvin
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

AIR AND ENERGY ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

The Control Air Toxics (CAT) program was funded as a cooperative project by EPA's Control Technology Center (CTC) and the New York Department of Environmental Conservation.

The CTC was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and Local air pollution control agencies. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

The technical guidance projects, such as this one, focus on topics of national or regional interest that are identified through contact with State and Local agencies. In this case, the CTC assisted the State of New York Department of Environmental Conservation, identify the scope and nature of methylene chloride emissions from the Kodak film manufacturing facility in Rochester, NY. Possible emissions control systems and strategies were also evaluated. The document discusses control technology for methylene chloride emission streams similar to those defined at the Kodak facility.

ACKNOWLEDGMENT

The Kodak, Rochester, NY, plant assessment study was prepared for EPA's Control Technology Center (CTC) and the State of New York Department of Environmental Conservation (NYDEC) by Stephen A. Walata III and Richard M. Rehm of Alliance Technologies Corporation. The project officers were Charles H. Darvin of EPA's Air and Energy Engineering Research Laboratory (AEERL), and Matthew J. Reis of NYDEC. Also participating in the project was Fred Dimmick of EPA's Office of Air Quality Planning and Standards (OAQPS).

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Metric Conversion Factors

Where the metric equivalent is not given in the text of this report, the following metric conversion factors may be used.

FROM	TO	MULTIPLY BY
BTU	Joule	1054
cu ft	cu meters (m^3)	0.028
cu ft per min (cfm)	cu meters per sec ((m^3/sec)	0.00047
feet (ft)	meters (m)	0.305
gallons (gal)	liters (l)	3.785
in. H_2O (60°F)	pascal (Pa)	248.8
mm Hg (32°F)	pascal (Pa)	1.33
pounds (lb)	Kilogram (kg)	0.454
pounds/sq in. (psi)	kilopascal (kPa)	6.894
sq feet (ft^2)	sq meter (m^2)	0.093

TO CONVERT	TO	MULTIPLY
Degree Fahrenheit (°F)	Degree Celsius (°C)	$t°_C = (t°_F - 32)/1.8$

1.0 EXECUTIVE SUMMARY

This report characterizes emissions and control technologies for reducing emissions of methylene chloride (also known as dichloromethane, or DCM) at Eastman Kodak Company's Kodak Park facility in Rochester, NY. From data provided by Kodak, DCM emissions at the Kodak Park facility total 9,200,000 pounds per year, the largest of any source in the United States. Kodak uses DCM in the manufacture of cellulose triacetate film support.

The assessment of control technologies for DCM emission sources at Kodak Park was initiated by New York State's Department of Environmental Conservation (DEC) in order to bring the facility into compliance with Title 6, Chapter III, Part 212 of New York State's air pollution regulations. This was due in part to New York reducing the acceptable ambient level for methylene chloride from 1167 to 0.37 µg/m3, and Kodak's plans to increase cellulose triacetate film production. DEC requested assistance from EPA's Control Technology Center (CTC) to independently evaluate control technologies which might be applied to DCM emissions at Kodak Park. Alliance Technologies Corporation was contracted by CTC to assist in this evaluation.

This report provides an introduction and background to this project, describes DCM emissions from Kodak Park, explains process changes indicated to be planned by Kodak to reduce DCM emissions, and assesses possible control technologies for reducing DCM emissions.

Work on this project focused on the evaluation of category 1 and category 2 emission points. According to Kodak, category 1 sources are those emitting greater than 100,000 pounds of DCM per year, while category 2 sources emit between 8,000 and 100,000 pounds per year. Of the 181 registered emission points at Kodak Park, 26 (15 percent) are classified as category 1 or 2. These sources, however, emit approximately 8,400,000 pound of DCM, or greater than 90 percent of all DCM emissions. During the control technology assessment it was determined that a substantial number of emission sources had emission estimates with a low confidence level. Of the 26 existing category 1 or 2 sources, emissions from 11 of the points were estimated by best engineering judgment. The accuracy of such estimates can be held suspect. Before serious consideration is given to applying a control device to any of the emission

points which were estimated using best engineering judgment, better emission estimates need to be obtained.

By far, the largest source of DCM emissions at Kodak Park comes from the production of cellulose triacetate film. In this process, triacetate pellets are dissolved in methylene chloride and other solvents to form "dope." The dope is then extruded onto a polished surface to form a thin sheet or web. The web is then dried at elevated temperatures, driving off the methylene chloride and other solvents. This process happens within roll coating machines which are enclosed. While Kodak recycles greater than 95 percent of the DCM used in this process, 7,380,000 pounds, or over 80 percent of total DCM emissions to the atmosphere occur from this process. Other sources of DCM emissions include the Dope Department, where triacetate pellets are dissolved in DCM, the Distilling Department, where DCM is distilled and recovered, fugitive emissions from pumps, valves, seals, flanges, etc. within Kodak Park, and secondary losses from wastewater.

By far, the assessment indicated that the greatest potential for emission reduction is by controlling leaks from the roll coating machines. Kodak has proposed to remedy this situation by changing latching devices and gasket seals, covering bearing casings, and installing solid pipe bulkhead fittings on the machine casing. These changes were projected by Kodak to reduce DCM emissions by 3,000,000 pounds per year. This assessment found no reason that this projection cannot be met. Kodak projects that work in this area will be completed in 1992. It is believed that this projected work schedule, however, can be significantly accelerated.

The remaining category 1 and 2 sources at Kodak Park can be divided into two groups. The first group consists of emission points which are already controlled, while the second group consists of uncontrolled sources. Emission controls used by Kodak include carbon adsorbers, dual water/methanol scrubbers, and condensers. A review of available data indicate that the scrubbers and condensers are not being operated efficiently, and significant emission reduction can be achieved by more efficient operations.

The majority of uncontrolled emission points have high flow rates and low DCM concentrations, making control difficult and expensive. Several points in this group, however, present situations where Kodak could recover DCM. These

include combining emission sources and adding a scrubber or carbon adsorber. In addition, emission reductions can also be achieved by controlling solvent loss from ultrasonic cleaning operations, and institution of a leak detection and repair program for valves, flanges, pumps, seals, etc. in DCM services.

Table 1-1 provides a summary of potential emissions reduction of emission sources examined by this report.

TABLE 1-1. SUMMARY OF EXPECTED EMISSIONS REDUCTION FROM POSSIBLE CONTROL TECHNOLOGIES

Emissions Point(s)	Description	Current Emissions, lb/yr	Emissions After Control, lb/yr	Percent Reduction	Reasonable Control Technology
53-85,53-38, and 20-68	Machine Room Exhaust	7,380,000	4,380,000	40.6	Improving Seals on Roll Casting Machines
53-22	C.A. for Machine Air Draw-Off	78,500	45,700	41.7	Improved Operations
142-1	Solvent Recovery Sys. Vent Scrubber	14,000	Cannot Determine		Improved Operations
120-7	Still System Vent Scrubber	8,700	Cannot Determine		Improved Operations
54-15	Building 54 Vent System	23,350	2,350	89.9	Improved Operations
52-37 and 54-29	Batch Mixers Felt Wash Process	237,835	23,784	90	Carbon Adsorber or Scrubber
53-32 and 53-96	Hopper Cleaning Storage Vessel Vents	41,900	2,095	95	Inclusion with Flows for the 18,000 cfm Carbon Adsorber
49-53	Ultrasonic Cleaner	10,000	4,000	60	Proper Freeboard Ratio Freeboard Chiller or C.A.
Fugitives	Equipment Leaks	650,000	390,000	40	Leak Detection and Repair Program

2.0 INTRODUCTION

This report presents the results of an assessment of potential control technologies for methylene chloride (also known as dichloromethane, or DCM) emission sources at Eastman Kodak Company's Kodak Park facility in Rochester, NY. DCM is a solvent used by Kodak in the manufacturing of cellulose triacetate film support.

The State of New York, Department of Environmental Conservation, requested EPA's Control Technology Center (CTC) assistance in the evaluation of control technologies which might be applied to DCM emissions sources at Kodak Park. CTC is responsible for supporting State and local air pollution control agencies in the implementation of their programs. Alliance Technologies Corporation was contracted by CTC to assist in this evaluation. Work has involved: 1) a plant visit where major DCM emission sources were inspected, and 2) evaluation of current and potential control technologies for the DCM emission sources. This report contains information gathered during the plant visit to the Kodak Park facility. Included are emission estimates determined by Kodak of all emission points greater than 8,000 pounds of DCM per year, as well as a description of each point observed during the visit. Also included in this report is an evaluation of control technologies which might be applied to the major emission sources. A cost analysis of different add-on control devices is provided for four of the uncontrolled emission points.

3.0 BACKGROUND

The assessment of control technologies for DCM emission sources at Kodak Park was initiated by New York State in order to bring the facility into compliance with Title 6, Chapter III, Part 212 of New York State's air pollution regulations. This was in part due to New York reducing the acceptable ambient level (AAL) for DCM from 1167 ug/m^3 to 0.37 ug/m^3. Another factor which lead to this study is Kodak's plans to increase acetate film support production. New York State's Department of Environmental Conservation (DEC) needed a means of independently evaluating possible control technologies which would reduce the DCM emissions from Kodak Park. To this end, the DEC requested the assistance of EPA's Control Technologies Center in the evaluation of potential control devices. The goal of this process is to provide the DEC with independently developed control scenarios for reducing the overall DCM emission from the Kodak Park facility.

Data for this study was collected during a visit to the Kodak Park facility on June 15-16, 1988. During the course of these two days, Alliance personnel were provided with a brief history of film support manufacturing, review of the processes which involve the use of DCM and emissions data pertaining to the DCM emission sources. Kodak provided a document in support of their use of DCM in the manufacturing of cellulose triacetate film support. This document can be found in Appendix A. Kodak provided schematic diagrams for the major processes which use DCM. These diagrams, however, will not be presented in this study due to confidential nature of the information the diagrams contain. The diagrams did provide Alliance personnel with some insight as to where in the process emission points were located. The emissions data provided by Kodak were for all category 1 and 2 emission points. According to Kodak, category 1 emission points emit greater than 100,000 pounds of DCM per year and category 2 emission points emit in excess of 8,000 pounds of DCM per year. Of the 181 registered emission points at Kodak Park in 1987, 26 (15 percent) are classified as category 1 or 2. The total amount of DCM emitted by the category 1 and 2 sources in 1987 was about 8,400,000 pounds. This accounts for approximately 90 percent of the 9,200,000 pounds of DCM released into the atmosphere by the Kodak Park facility in 1987.[1] Kodak provided the emission estimate for each point and background information as to how each estimate was calculated. A summary of the emission points and amounts

emitted at Kodak Park are listed in the next section. For the most part, overall DCM emissions from Kodak Park are calculated by means of a material balance, while the DCM emissions for many specific processes are determined from best engineering judgement.

Alliance personnel were taken on a tour of the processes which use DCM. During the plant tour, direct observation of 19 emission points was possible. This accounts for 82 percent of the total category 1 and 2 emissions. Information gathered during this part of the plant visit was helpful in the determination of space constraints surrounding each emission point and provided a better understanding of how emissions are related to the processes. This information was valuable in the selection of potential control technologies.

REFERENCES

1. Data supplied by J.D. Mathews, Eastman Kodak Company, to R.M. Rehm and S.A. Walata, Alliance Technologies Corporation, during the plant visit at the Kodak Park facility. June 15 and 16, 1988.

4.0 EMISSIONS

INTRODUCTION

The purpose of this section is to provide a brief description of DCM emissions at the Kodak Park facility. DCM emissions occurring at this facility come from either registered emissions points, fugitive losses from equipment leaks, or secondary emissions from wastewater. The numbers presented in this section comprise a partial inventory of DCM emissions generated from these sources.

REGISTERED EMISSIONS POINTS

DCM emissions generated through registered emissions points are from processes involved with the manufacturing of cellulose triacetate film support. In keeping with the scope of this study, only the category 1 and 2 emissions points will be dealt with in this section. As defined earlier, category 1 emission points emit greater than 100,000 pounds of DCM per year, and category 2 emission points emit in excess of 8,000 pounds of DCM per year. A list of the emission points consider in this section is presented in Table 4-1. At the Kodak Park facility, three departments (Dope, Roll Coating and Distilling) are the main users of DCM. The following is the emission points within each department.

Dope Department

The Dope Department is where cellulose triacetate pellets are dissolved into a blended solvent, the major constituent of which is DCM, to form a liquid polymer referred to as "dope." The dope is then processed for further use in the Roll Coating department. This department has seven emission points which are of interest to this study. The largest of these points is the emissions resulting from the charging of batch mixers (point 52-37) with cellulose triacetate. In past years, all of the cellulose triacetate was dissolved in this fashion, but since the advent of continuous mixers, batch mixers account for only a small percentage of dope generation. Emissions of DCM of the category 1 level occur when the batch mixers are being charged. The solvent is

TABLE 4-1.
DCM EMISSION POINTS AT KODAK PARK FACILITY

SOURCE	DESCRIPTION	CATAGORY	DEPT. LOCATION	STACK HEIGHT (ft.)	FLOW RATE (CFM)	EMISSIONS (lb/yr) ACTUAL YEARLY	AVG. HR.	PEAK HR	METHOD OF ESTIMATION
53-85	EXISTING MACHINE ROOM EXHAUST	1	ROLL COATING	80	250000	4700000	537	700	Monitoring
53-38	EXISTING MACHINE ROOM EXHAUST	1	ROLL COATING	80	125000	1300000	150	200	Monitoring
20-68	EXISTING MACHINE ROOM EXHAUST	1	ROLL COATING	60	150000	1380000	158	420	Best Engineering Estimate*
52-37	BATCH MIXERS	1	DOPE DEPT.	70	1110	193680	66.3	66.3	Best Engineering Estimate
53-K1	FLOOR SWEEPS FOR SOLVENT RECOVERY ROOM	1	ROLL COATING	35	20000	150000	17.2	20.4	Monitoring
53-88	FLOOR SWEEPS - DOPE DEPT.	2	DOPE DEPT.	85	34400	86724	9.9	10.2	Best Engineering Estimate
53-22	EXISTING C.A. FOR MACHINE AIR DRAW-OFF	2	ROLL COATING	100	4000	78500	9	9.6	Monitoring
53-08	FILTER PRESS CHANGING	2	DOPE DEPT.	83	15000	75680	104	104	Monitoring
329-2	2ND DRYER TO CARBON ADSORBER	2	ROLL COATING	61	27500	45786	35.3	177	Material Balance
54-29	FELT WASH PROCESS (5 FILTERS)	2	DOPE DEPT.	35	1	44155	40.3	42.5	Best Engineering Estimate
317S0	305 MACHINE CARBON ADSORBER EXHAUST	2	ROLL COATING	82	18000	42670	11.9	11.9	Material Balance
53-K2	EAST END FLOOR SWEEPS	2	ROLL CASTING	85	9000	36500	4.2	5.0	Monitoring
21-12	KADY MILL EXHAUST	2	ROLL COATING	62	5500	35580	106	201.5	Best Engineering Estimate
322-4	KPM SOLVENT RECOVERY REFIG. CONDENSER	2	DISTILL	30	15	32000	3.7	97.6	Monitoring
329K2	VESSEL CLEANING EXHAUST	2	ROLL COATING	46	4100	27450	18.3	18.3	Best Engineering Estimate

* Estimate based on the monitoring results for 53-85 and 53-38.

(Continued)

TABLE 4-1. (CONTINUED)
DCM EMISSION POINTS AT KODAK PARK FACILITY

SOURCE	DESCRIPTION	CATAGORY	DEPT. LOCATION	STACK HEIGHT (ft)	FLOW RATE (CFM)	EMISSIONS (lb/yr) ACTUAL YEARLY	AVG. HR.	PEAK HR	METHOD OF ESTIMATION
D63-5	STEAMER CHARGING EXHAUST	2	DISTILL	28	3550	26280	3	3	Best Engineering Estimate
54-15	BUILDING 54 VENT SYSTEM	2	DOPE DEPT.	70	5.5	23350	2.67	25	Best Engineering Estimate
53-96	STORAGE VESSEL VENTS	2	ROLL COATING	75	1	22900	2.6	4.8	Best Engineering Estimate
53-32	HOPPER CLEANING AND FLOOR SWEEPS	2	ROLL COATING	77	11200	19000	2.1	110	Monitoring
52-M2	WEST WALL EXHAUST FAN - 1ST FLOOR	2	DOPE DEPT	8	6000	17800	2	2	Best Engineering Estimate
53-92	SOLVENT DYE MIXING (FLOOR SWEEP SYSTEM)	2	ROLL COATING	80	12000	15000	1.7	6.4	Best Engineering Estimate
52-M3	WEST WALL EXHAUST FAN - 2ND FLOOR	2	DOPE DEPT.	30	5300	14500	1.7	1.7	Best Engineering Estimate
142-1	FILM SOLVENT RECOVERY SYS. VENT SCRUBBER	2	DISTILL	48	9	14000	1.9	1.9	Monitoring
317S2	306 MACHINE CARBON ADSORBER EXHAUST	2	ROLL COATING	88	40000	10000	27.8	27.8	Material Balance
49-53	ULTRASONIC CLEANER	2	ROLL COATING	65	1746	10000	1.14	11	Material Balance
120-7	STILL SYSTEM VENT SCRUBBER	2	DISTILL	91	3	8700	1.2	1.2	Monitoring
					TOTAL	8410255			

Material Balance — The known flows of DCM into and out of a process are subtracted from one another to yield an estimate of DCM air emissions.

Best Engineering Estimate — Calculations are made on physical/chemical properties of the materials present, and standard engineering equations. If insufficient information is available then engineering judgment and experience with similar processes are used to estimate DCM emissions.

Monitoring — Samples are taken and analyzed for DCM concentratioon. The concentration is combined with air flow measurements to yeild an estimate of DCM emissions.

first loaded into the mixer, then the top is opened and the cellulose triacetate is poured in. Solvent vapors are released when the solids are added to the fluids. The charging ports are fitted with a cooling jacket to condense solvent vapors and reduce possible emissions during the loading operation. The vapors that escape from the charging ports are then discharged into the atmosphere after passing through a cyclone to remove particulate matter. The equations used by Kodak to estimate the DCM emissions from this operation were developed some fifty years ago when the batch mixers were utilized more often. These emissions estimates have not been revised although the use of the batch mixers has decreased. Kodak personnel believe that the emissions estimates they have reported are greater than current actual annual DCM emissions. Given the reduced use of the batch mixers and that the estimation equation was developed without monitoring data to confirm its accuracy, Alliance agrees with the assessment that the reported emissions are probably an overestimation.

Two other emission points of interest are the result of two different filtering operations during the dope refining process. The emissions from the filtering operations occur when the filter elements are being changed. The largest of these two sources is the filter press changing operation (point 53-08). A series of filter presses are located in Building 53 and when the elements are changed any DCM vapors are force vented to the atmosphere. This is to keep the ambient level of DCM in the building at a safe level for the workers. The other filtering operation which results in DCM emissions is the felt wash process (point 54-29). The felt wash process removes solid matter from the excess solvent before the solvent is placed in a storage tank to await transport to the Distilling Department. The felt washers are located on a catwalk outside of Building 54. When the filter elements are changed, the DCM vapors escape directly into the atmosphere. Kodak personnel estimate that two felt wash tanks are changed per day.

The remaining four emission points in the Dope Department deal with the general ventilation of the buildings housing the department and the venting of storage tanks. The largest of these points is the floor sweeps in the Dope Department (point 53-88). The floor sweeps are ducted vents on floor level which draw off floor level concentrations of DCM vapors. These vapors are then vented into the atmosphere through a vent on the roof. The floor sweeps in the Dope Department are located around the filter presses and pumps. Another emission point is the vent system which receives emissions from ten storage

tanks, each of which has a capacity of ten thousand gallons (point 54-15). The control equipment on this emission point includes a condenser and a nitrogen blanket which are used to recover DCM vapors caused by the emptying and filling of the tanks. The remaining two emission points in the Dope Department are exhaust fans in the west wall on the first and second floors of Building 52 (points 52-M2 and 52-M3). The exhaust fans are used for general ventilation purposes and emit DCM directly to the atmosphere.

Roll Coating

The Roll Coating department accounts for 93.6 percent (7,873,386 lb/yr) of the category 1 and 2 DCM emissions at Kodak Park through 16 registered emission points. Kodak personnel estimate that 7,702,350 lb/yr of DCM emissions are associated with the process of film base casting. Film base casting is the operation where the cellulose triacetate dope is extruded on a polished surface to form a thin sheet or web. The web is then dried at elevated temperatures. Three registered emission points associated with this process (points 53-85, 53-38 and 20-68) accounts for over 80 percent (7,380,000 lb/yr) of the total DCM emissions at Kodak Park each year. These emission points are the exhaust stacks for the ventilation system for the film base casting rooms in Buildings 53 and 20. Kodak employs a simple method to ventilate the rooms which contain the roll casting machines. Air is forced into the base of the building and is vented to the atmosphere along with the DCM through the roof. Powered exhaust fans are present in Building 53 (point 53-85) which assist in ventilating the building. The air flow is aided in its upward motion by the "chimney effects" which occur between the casting machines due to the high temperatures. Information of the ventilation system of each casting room is presented in Table 4-1. The large volumes of air being pumped through each casting room serves two purposes: 1) to maintain an ambient level of DCM within OSHA guidelines, and 2) to provide comfortable working conditions around the film base casting machines.

The DCM emissions in the ventilation exhaust are what Kodak terms "captive fugitives." These are fugitive emissions from the casting machines which are released into the room before they are vented to the atmosphere through the emission points. Figure 4-1 shows the general design of a roll casting machine. Each machine has various areas where DCM could be released

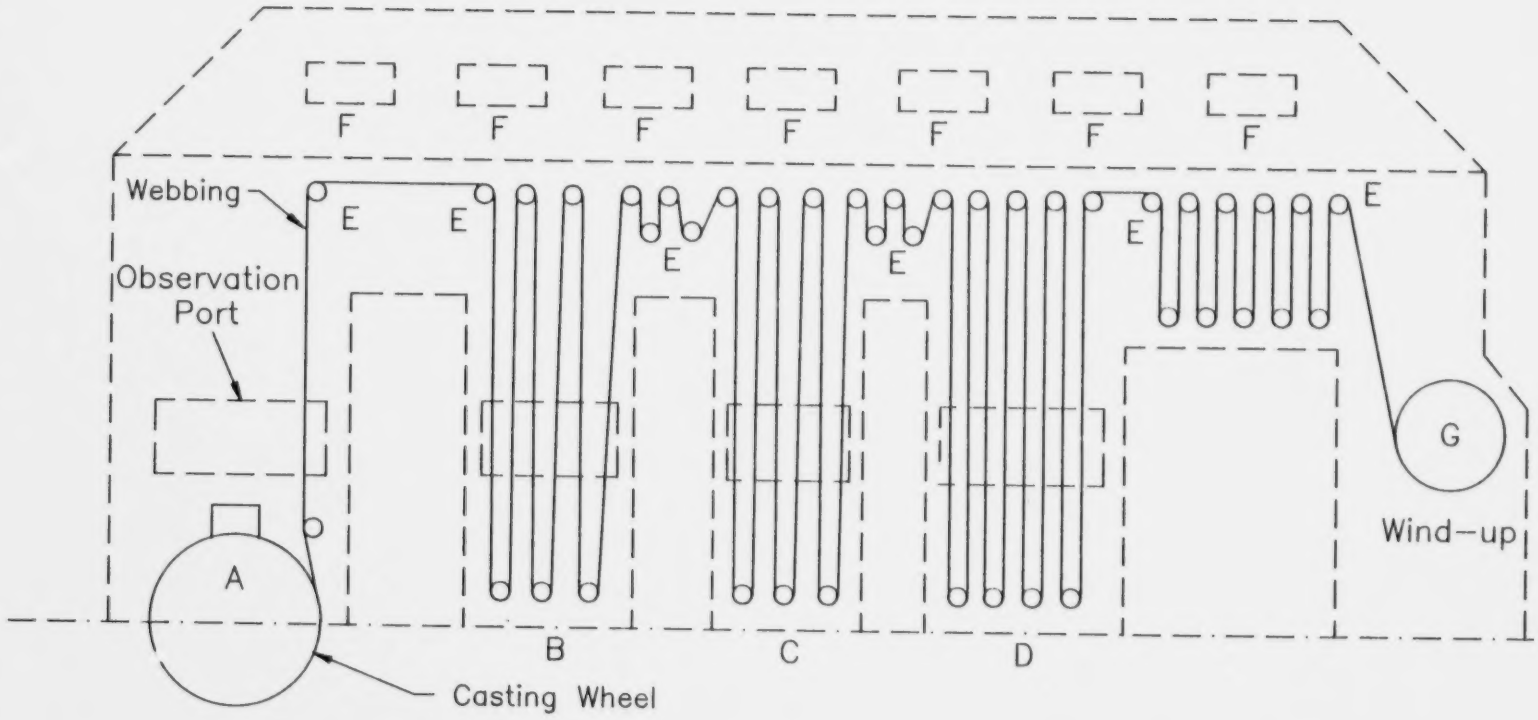

Figure 4-1. Diagram of Roll Coating Machine

into the casting room. The cumulative emissions from the casting machines in Building 53 constitutes the single largest source of DCM emissions at Kodak Park. The area labeled "A" in Figure 4-1 is the hopper compartment where the dope is extruded on and later stripped off the polished surface or casting wheel. This is where the DCM vapors are the most concentrated since almost all of the DCM in the dope is being vaporized in the formation of the web. There are vents located in this hopper where the web is stripped off of the casting wheel. These vents capture DCM vapors for solvent recovery. Seals around the observation and access ports as well as openings in the machine's casing for hoses and tubes are a source of DCM emissions in this hopper of the machine. This area of the machine may very well be the source of a majority of the DCM fugitive emissions generated from the process. Areas labeled "B","C", and "D" are hoppers in which application solutions are applied to the web. These solutions may or may not contain DCM. There may be DCM emissions from the observation and access ports but not on the same level as the first hopper since most of the DCM should be vaporized when the web was formed. The areas labeled "E" are the bearing housings for the idler rollers located throughout the casting machine. This area is not sealed and Kodak personnel feel that DCM can and does escape through the bearings. Alliance personnel concur that there is a potential for fugitive emissions to occur through the bearings since they are not sealed. The areas labeled "F" are the locations of pressure relief vents which are needed in the unlikely event of an explosion inside the machine. These panels are secured to the machine housing with double backed tape. Due to the nature of this design, it is not uncommon to have leaks from these panels from time to time. The area labeled "G" is the wind-up of the web into a roll for storage purposes. This area is effectively a large opening in the end of the machine where Kodak personnel feel that some DCM does escape from the machine. Alliance believes that this area is a minor source of DCM emissions from the casting machine.

In each of the film base casting machines are vents which capture DCM vapors for solvent recovery purposes. Although the casting machines lose what seem to be a large amount in fugitive emissions, most of the DCM used in the cellulose triacetate film manufacturing is captured for reuse. From the data provided by Kodak, Alliance estimates that approximately 95 percent of the DCM used is recycled.[1] The solvent recovery system for film base casting is a closed system which circulates air as a carrier gas from the casting machine to

a brine condenser and back to the casting machine. The brine condenser operates at a temperature of -88°F. This causes the DCM in the air to return to the liquid phase for transportation purposes to the Distilling Department. After the brine condenser on several of the casting machines, a side stream of air containing DCM is removed from the air flow and passed through a carbon adsorber. The reason for removing the side stream is to allow pressure balancing in the casting machines. The reason for passing the side stream through the carbon adsorber is to recover the DCM in the side stream. Kodak personnel reported that the carbon adsorber is 95 percent efficient in the removal of DCM from the air flow.[2] Thus, the exhaust from the carbon adsorber contains DCM and is considered an emission point (point 53-22). There are also DCM emissions which are caused by equipment leaks around the brine condensers. These emissions are collected by floor sweeps in the west end and east end of Building 53 (points 53-K1 and 53-K2). These floor sweeps are vented directly to the atmosphere. The amount of DCM discharged by 53-K1 and 53-K2 are 150,000 and 36,500 pounds per year respectively. These estimates were derived from a method of estimation which used monitor data.

There are three other emission points which are directly associated with the casting process. The first is the vents system on storage tanks containing surface coating solutions (point 53-96). The solutions are prepared in the morning and used during the course of the working day and may not always contain DCM. The vent on each of the tanks is a "U" shaped duct which is vented through the roof to the atmosphere. The second point consists of the vents and floor sweeps in the hopper cleaning area (point 53-32). In this area the parts which extrude the dope onto the casting wheel are cleaned by soaking in a bath of DCM. There are vents which surround each bath and floor sweeps to collect and DCM vapors at floor level. The DCM collected by these vents is then exhausted through the roof to the atmosphere. The last emission point is associated with the area for solvent dye mixing (point 53-92). This area consists of several 500 gallon tanks where the dye is prepared for use on the web. The ventilation in this area is a localized exhaust which is vented through the roof to the atmosphere.

There are several other emission points which are due to processes which use DCM. Three of these points are the exhaust from carbon adsorbers. Two of the carbon adsorbers are located in Building 317 (points 317S0 and 317S2) and the third is located in Building 329 (point 329-2). These carbon adsorbers are

used as the solvent recovery system in surface coating processes. In a surface coating process, application solutions are applied to rolls of various film substrate. Air is used as a carrier gas for the DCM as it vaporizes from the web. For some film products, DCM is not used in the application solution. Kodak personnel reported that the carbon adsorbers are 95 percent efficient in removing DCM from the air flow and thus will discharge DCM into the atmosphere.[2] Another point located in Building 329 is the exhaust from the vessel cleaning area (point 329K2). DCM is used to clean out tanks which contain the application solution. The emissions of DCM only occur when the vessel is open for inspection. These emissions are collected by a localized venting system and discharged to the atmosphere.

Other emission points associated with manufacturing operations are the Kady Mill exhaust (point 21-12) and the ultrasonic cleaner (point 49-53). The Kady Mill is a grinding operation which uses DCM in the grinding process. DCM is also used to clean the vessel. The DCM emissions from the Kady Mill occur when the vessel is opened for inspection. The DCM emissions are then collected by a "U" shape vent at the rim of the vessel, channeled through the roof and discharged into the atmosphere. Kodak personnel informed us that the Kady Mill in recent years has only operated for a two week period each year. They feel that the emissions reported from this operation are an over estimation of current operations. The ultrasonic cleaner uses DCM to remove particulate matter from photo-sensitive glass plates. The operation of this process is analogous to a degreasing operation. Current controls for DCM emissions on the Ultrasonic cleaner include a primary condenser to condense DCM vapors, and draining the unit when not in use. A collection hood is present above the cleaner to capture emissions and is combined with floor sweeps from the room to a common duct and vented to the atmosphere through the roof.

Distilling Department

The Distilling Department is the area at Kodak which refines used DCM into a product which is reusable in the acetate film manufacturing. DCM emissions from the four points in this department are all of the category 2 classification. The DCM refining is accomplished, as the name implies, by the distillation of the used DCM to separate it from the other liquid components which may be present. The Distilling Department has two areas which are in

DCM service, the KPW site and the KPM site. The KPW site handles the bulk of the DCM processed in a given year because it handles the used DCM from the acetate film base manufacturing areas. The KPM site handles the used DCM from the several surface coating processes from Buildings 317 and 329. Each site has a tank farm for storage of the used and refined DCM and the distillation columns. The storage tanks and distillation columns are vented to methanol/water scrubber systems. The methanol scrubber is used to remove the DCM present in the air flow, while the water scrubber removes light, water soluble solvents or methanol remaining in the air flow. Two of the scrubber systems are located at the KPW site. One system handles the vent flows from the tank farms located there and the distillation columns located in Building 120 (point 120-7). The other system is for the vent flows from the distillation columns and the DCM containing process tanks located just adjacent to Building 120 (point 142-1). A refrigerated vent condenser system is located at the KPM site where it handles the vent flows from the storage tanks and distillation columns located there. Kodak estimates that these vent control devices are 90, 94 and 86 percent effective respectively in the removal of DCM from the vent flows.

The one other DCM emission point worth noting in the Distilling Department is the steamer charging exhaust (point D63-5). At the Kodak Park facility, liquid streams containing DCM and solids are treated in the steamer in order to recover the DCM. These streams are transported from their point of origin in portable tanks and placed in a steamer pot where steam removes the DCM for further treatment in the distillation process. The remaining solids and water are then transported to Kings Landing Wastewater Treatment facility for further treatment before discharge to the environment. When the solids are transferred from the portable tanks to the steamer pot, DCM emissions occur. These emissions are collected by a localized venting system and discharged into the atmosphere.

SECONDARY EMISSIONS

The Kodak Park facility has its own wastewater treatment facility located on the banks of the Genesee River at Kings Landing. This facility handles 30 million gallons of industrial wastewater per day from Kodak Park. The system

is acclimated for chlorinated organics, and a study done in 1986 using an on-line gas chromatograph showed an 80 percent degradation of DCM from the influent concentration. There are, however, certain areas that have a potential for generating secondary emissions from the treatment facility. The two areas with the greatest potential are the grit chamber and the distribution section to the primary settling tanks. These are two areas where turbulent water is exposed the atmosphere prior to any biological degradation. Kodak estimates the secondary emissions from Kings Landing are 66,000 lb/yr. Kodak personnel at the time of the inspection could not provide detailed information on the sources of DCM in the wastewater streams.

FUGITIVE EMISSIONS

At the Kodak Park facility, fugitive emissions of DCM are divided into two categories. This first category is designated by Kodak as "captive" fugitive emissions. These emissions, as defined above, are those generated from equipment located in a building and are contained by the building before being vented to the atmosphere through a registered emission points. The emission estimates from this type of fugitive emissions were discussed in the sections above.

The other type of fugitive emissions at Kodak Park are of a more "standard" nature. These emissions are the result of leaks from pumps, valves flanges, seals, and other equipment which is in DCM service and are discharged directly to the atmosphere. Kodak estimates that 650,000 lb/yr of DCM are emitted to the environment through this type of fugitive emissions. Kodak made this estimation through a plant level material balance of DCM. Kodak personnel however have not made a count of the number of pumps, valves, flanges, seals, etc. in DCM service in order to characterize the fugitive DCM emissions occurring from Kodak Park.

REFERENCES

1. Data supplied by J.D. Mathews, Eastman Kodak Company, to R.M. Rehm and S.A. Walata, Alliance Technologies Corporation, during the plant visit of the Kodak Park facility. June 15 and 16, 1988.

2. Letter from B.M. Wirsig, Eastman Kodak Company, to S.A. Walata, Alliance Technologies Corporation. September 12, 1988.

5.0 PROCESS CHANGES PLANNED BY KODAK

During the course of the plant visit, Kodak personnel made a presentation of process changes which were being planned. All of the process changes discussed were associated with the film base casting process. As described in Section 4, emissions from the film base casting machines account for 7,380,000 pounds per year, or over 80 percent of entire DCM emissions from Kodak Park. Changes include modification to the film base casting machines and the replacement of the carbon adsorber used to pressure balance several machines with a large capacity unit.

One of problem areas in the roll casting machines is the DCM leaking from the observation and access ports due to the lack of air tight seals. Kodak is proposing to remedy this problem by changing the latching device and gasket seals. In the areas of the machine which have high concentrations of DCM vapors, Kodak is planning on replacing the current latches with a spring loaded type which has a leverage feature built in. This will allow for the port to be cranked down tight. The gaskets in these areas will be replaced with a bladder type gasket which will allow for a pressurized seal. The pressurized seal would be achieved by inflating the bladder type gasket with air. This would result in a tight, custom fit between the port and machine housing. Latches in the other areas will be replaced with screw type latches for a tight fit. Another problem area is the DCM leakage through the bearing casings of the idler rollers. Kodak plans to fit each bearing casing with a "bubble cap" which will seal each bearing. Kodak also plans to install solid pipe bulkhead fittings on the machine casing. This will seal up the openings in the machine's casing which are required for the various tubes and pipes which supply the application solutions for the web. Also discussed were possible changes which could be made for the pressure relief vents. Kodak is in the process of reviewing the type of tape used to attach the panels for the vents to the machine casing as well as the installation technique used. Kodak is also looking at other means of securing these panels. Another possible modification to the casting machine design would be to build a buffer between the last curing hopper and the web wind up using a hot air purge system. Kodak plans to design this feature into their new casting machine but it is unclear at this time if the older machines would be retrofitted with this feature.

Kodak personnel also discussed plans for the replacement of the carbon adsorber used in the Roll Coating Department to pressure balance several of the film base casting machines in Building 53. The current carbon adsorber has a capacity of 4,000 cfm. This allows Kodak to pressure balance only six of the nineteen machines located in Building 53's casting room. The new carbon adsorber would have a capacity of 18,000 cfm and would allow all the casting machines to be pressure balanced. This increased flow capacity would allow Kodak the latitude to control emissions from currently uncontrolled sources. During the visit to the hopper cleaning area in Building 53, Kodak personnel indicated that there were plans to include the vents from the hopper cleaning baths in the flows to the new carbon adsorber.

Kodak estimates that DCM emissions will be reduced by 3,000,000 pounds per year by controlling fugitive losses from the film base casting machines and by installation of the new carbon adsorber. According to Kodak's p·esent timetable, all film base casting machines will be retrofitted with the equipment described above by 1992. The new carbon adsorber will be on-line by 1991.

6.0 CONTROL TECHNOLOGIES ASSESSMENT

The purpose of this study is to provide a broad analysis of the control technologies used to reduce DCM emissions and the feasibility of their use at Kodak Park. A cost analysis is also provided for the controls on four emission points at Kodak Park. This analysis makes use of the EPA Handbook, "Control Technologies for Hazardous Air Pollutants."[1] The handbook describes two types of devices which can be used to control DCM emissions: combustion and solvent recovery.

The main advantage of using combustion control devices is that they can provide a high control efficiency of DCM emissions. Combustion type control devices cause the destruction of a compound through oxidation of the molecular bonds. A list of control devices of this type is presented in Table 6-1. When hydrocarbons are oxidized, the resulting compounds are ideally water and carbon dioxide. This, however, is not the case when DCM is oxidized due to the fact DCM is a halogenated hydrocarbon. Basic stoichiometry of the oxidation reveals the chlorine atoms present in DCM will bond with free hydrogen atoms to form hydrogen chloride (HCl). The formation of HCl would require the addition of an extra control device to the original control device, since HCl is also considered a potentially hazardous air pollutant. The corrosive nature of HCl, when in the presence of water, would also require the control devices to be constructed of high grade materials which are resistant to corrosion. These two requirements would increase the initial capital cost for the control device. Another problem with the combustion of DCM is the energy requirements to cause its oxidation. One reason for DCM being the solvent of choice in the manufacturing of acetate film is its non-flammable nature. This property causes the need for a fuel to be added to the air stream to facilitate combustion for thermal incineration. The cost of the fuel for combustion or heat will add to the annual operating cost of the control devices. On top of this the cost of replacing the lost DCM must also be taken into account. This cost would normally be incurred for operations in their present state of not having controls. Since this analysis is reviewing the options of whether best control technology for DCM emissions is through combustion or recovery devices, the cost of replacement DCM must also be considered.

Recovery type control devices are those which physically remove a compound, such as DCM, from an emission stream and convert the compound into a

TABLE 6-1. POSSIBLE CONTROL TECHNOLOGIES FOR DCM EMISSIONS

COMBUSTION TYPE CONTROL DEVICES
INCINERATION
Thermal
Catalytic
FLARE
BOILER/PROCESS HEATER
RECOVERY TYPE CONTROL DEVICES
CARBON ADSORBER
SCRUBBER
CONDENSER
VAPOR RETURN
EQUIPMENT MODIFICATIONS
MODIFICATIONS TO OPERATING PROCEDURES
SPRING LOADED LATCHES
BLADDER GASKETS
CAPPED BEARINGS
SEALING TO PRESSURE RELIEF VENTS

form for future use, usually in a liquid form. A list of control devices of this type is also presented in Table 6-1. The means of physically removing DCM can be accomplished by adsorption, absorption or through a phase change which occurs when using a condenser. Each of these devices requires energy at some point of their operations. Absorption type control devices tend to be energy passive while condensers are more energy intensive. The main problem with control devices of this type is the recovery of other compounds other than DCM. Since the DCM recovered is to be used again, it must be separated from the other compounds. This step requires its own pieces of equipment and their associated costs in initial investment and operation. If such separation equipment already exists on site, then consideration must be given to whether the stream from this control equipment would exceed the capacity of this equipment. Also, consideration must be given to whether this new stream containing DCM would increase the current cost of refining DCM. The main advantage of using recovery control devices is in the fact that every pound of DCM recovery means one less pound which would have to be purchased to replace that which is lost in the emission stream.

When considering a control device for any of the category 1 and 2 emission points, one must pay special attention to the space requirement of the control device along with the other engineering considerations. The buildings where the majority of DCM usage takes place (Buildings 20, 52, 53 and 54) are in the older section of Kodak Park. Subsequent urban growth by the City of Rochester has greatly reduced the amount of available land in that area for further construction. This means that any control device selected should be housed either in an existing facility or a facility which can be constructed on land already owned by Kodak.

CONCLUSIONS

It is difficult to perform a BACT analysis on the DCM emission points at Kodak Park. The first problem encountered is a substantial amount of emission data with a low confidence level. Of the 26 existing category 1 and 2 emission points, 11 of these points had their emissions estimated by best engineering judgement. The accuracy of such estimates can be held suspect. There were at least two instances (emission points 52-37 and 21-12) where Kodak personnel suggested that the emission estimates provided for each point was higher than

the actual emissions. Because total DCM emissions from Kodak Park are based on mass balance, this raises the question if the emissions from points 52-37 and 2i-12 are actually lower than what Kodak says, are there points for which the actual emissions are greater than the estimates report? This provides the possibility that the analysis process suggest a control device for an emission source which may be impractical to control while ignoring another emission source that deserves consideration for control. Before serious consideration of applying a control device to any of the emission points which were estimated by best engineering judgement, better emission estimates need to be obtained. This effort should not be too difficult since all but three of these points are the result of captured uncontrolled fugitives being vented to the atmosphere through a duct. A monitoring program can be established for each point on a short-term basis to develop a better means of estimating emissions from each point. Kodak should also should evaluate the methods used to estimate the emissions from category 3 emission points. To do this would ensure that no DCM emission point is misclassified, and that all DCM emissions estimates are determined by the best possible means.

Another complication to the BACT analysis of the DCM emission points is the fact that over 80 percent of the total DCM emitted at Kodak Park is the result of three emission points (points 53-85, 53-38 and 20-68). These are the emission points associated with the ventilation of the film base casting rooms in Buildings 53 and 20. The flowrates through these rooms are such that any control device applied to controlling DCM emissions would have to be large enough to require its own building. To lower the air flowrates through these rooms in order to use a smaller control device would put Kodak personnel's health in jeopardy. A control device for these emission sources will be considered later in this section as part of an overall control strategy for Buildings 53 and 20. A more effective way of controlling the DCM emissions from these two rooms would be to control the emissions at the source, the film base casting machines. As discussed earlier Section 5, Kodak has made plans for modification in the sealing of the film base casting machines. Kodak personnel estimate the reduction in DCM emissions as a result of these modifications would be approximately 3,000,000 pounds of DCM per year. This would represent a 40.6 percent reduction in the DCM emissions from the three points and an overall reduction of DCM emissions from Kodak Park of 33 percent. Alliance believes that the current schedule for modifications can be

accelerated and recommends that Kodak complete this project at the earliest possible date. Kodak should also continue in their efforts to find more efficient ways of sealing the film base casting machines concentrating on the observation and access ports, pressure relief vents, bearing seals and seams in the machine casing. The goal of this program should be to provide an air tight casing for the film base casting process.

Alliance personnel lack the expertise of Kodak personnel regarding the film base casting machines and thus can not accurately provide an independent confirmation of the reduction estimates. Common sense, however, dictates that if the emissions in question are caused by leaks in the film base casting machine casing, then sealing the leaks will cause a reduction in the emissions. Kodak will have the means to verify the success of their modification program and should do so. As of this study, Kodak is installing a continuous monitoring system in the attic and vent ports of the casting room in Building 53. They have already used monitoring data from a prototype system in this area to estimate the emissions from this room. Once installed, a continuous monitoring system should provide Kodak with the ability of determining whether modification made to the film base casting machines result in the reduction of emissions. A similar system should be installed in the attic space of the film base casting room in Building 20. Since the emission from the casting rooms in Building 53 and 20 constitute a majority of DCM emission at Kodak Park, the emission estimates made by Kodak should have the highest degree of confidence. The remaining 23 category 1 and 2 DCM emissions points at Kodak Park can be divided into two groups. The first group consists of emission points which are the effluent streams from recovery devices already in place. A list of these emission points is presented in Table 6-2 along with the concentration of DCM in the effluent stream. Four emission points are effluent streams from carbon adsorbers (points 53-88, 329-2, 317S0 and 317S2), two are effluent streams from packed bed scrubbers (points 142-1 and 120-7) and two are the effluent stream from a condenser (points 322-4 and 54-15). The concentration of DCM in the effluent streams were calculated from the yearly emission and flowrate data provided by Kodak during the plant visit. Each device was assumed to be in operation year round, 24-hours a day. A sample calculation for the effluent concentration is presented in Table 6-3. The concentration values presented for the scrubbers and condensers can only be considered approximate values for reasons described later in this section.

TABLE 6-2. CONTROL DEVICES AT KODAK PARK

Source	Description	Flowrate, cfm	Actual Emissions, lbs/yr	Conc., ppm
53-22	EXISTING C.A. FOR MACHINE AIR DRAW-OFF	4,000	78,500	172
329-2	2ND DRYER TO CARBON ADSORBER	27,500	45,786	15
317S0	305 MACHINE CARBON ADSORBER EXHAUST	18,000	42,670	21
322-4	KPM SOLVENT RECOVERY REFIG. CONDENSER	15	32,000	18,714
54-15	BUILDING 54 VENT SYSTEM	6	23,350	34,139
142-1	FILM SOLVENT RECOVERY SYS. VENT SCRUBBER	9	14,000	13,646
317S2	306 MACHINE CARBON ADSORBER EXHAUST	40,000	10,000	2
120-7	STILL SYSTEM VENT SCRUBBER	1	8,700	76,319

TABLE 6-3. SAMPLE CALCULATION FOR EFFLUENT CONCENTRATIONS

SAMPLE EMISSION POINT 53-22

$$78{,}500 \text{ lb/yr} = 0.149 \text{ lb/min}$$

CONCENTRATION

$$(0.149 \text{ lb/min}) / (4{,}000 \text{ ft}^3\text{/min}) = 3.733\text{E-}5 \text{ lb/ft}^3$$

$$3.733\text{E-}5 \text{ lb/ft}^3 = 0.598 \text{ g/m3}$$

$$0.598 \text{ g/m}^3 \times 288^{*} = 172.16 \text{ ppm}$$

* See Reference 4.

While these emission points are controlled, this does not mean further emission reductions cannot be achieved. The carbon adsorbers, with the exception of the one, have effluent concentrations which are within the achievable concentration defined by the EPA.[2] This effluent concentration is defined by EPA as being less than 100 ppm. The carbon adsorber which has an effluent concentration greater than 100 ppm (point 53-22) is associated with the side stream being pulled off of six roll casting machines in Building 53 as a means to pressure balance these machines. During the plant visit, Kodak personnel informed us of plans to replace this carbon adsorber with another which will have a flow capacity of 18,000 cfm (the present carbon adsorber has a flow capacity of 4,000 cfm). This will give Kodak enough capacity to pressure balance all the casting machines located in Building 53. Since this new carbon adsorber will not be on line for several years, Kodak personnel should examine the operating parameters of the currently operating carbon adsorber to see if the effluent concentration can be reduced to at least 100 ppm. If the effluent concentration can be reduced from 172 ppm to 100 ppm, over the course of a year DCM emissions from this point will be reduced by 32,800 pounds.

The data supplied for the packed bed scrubbers operating in the Distilling Department indicate that their current use is not resulting in the maximum reduction DCM from the respective emission streams. The first indication can be found in the effluent concentration from each scrubber system. From the data provided by Kodak, the concentration of DCM in the emission streams of points 142-1 and 120-7 following control are 24,574 and 76,354 ppm respectively. The manual that EPA provides for the sizing of control devices suggests that a scrubber system best works when the influent concentration is no greater than 10,000 ppm.[3] Since the effluent concentration from the scrubber is over 10,000 ppm, then one must assume that the influent concentration is over 10,000 ppm. Another problem with the scrubber systems can be found in the fact that each is being used as a control device for vent streams which can have highly fluctuating concentrations of DCM. Such is the case as with the scrubber associated with emission point 120-7. This scrubber controls the vent flows from the storage tanks around Building 120. The concentration of DCM in these vent flows can approach the saturation point (this concentration is defined as being 550,000 ppm).[4] A concentration of this magnitude could easily overwhelm the scrubber's ability to effectively reduce the DCM concentration from the influent stream. This problem can be corrected

by adding a dilution stream to the influent stream. This would allow the influent concentration to be reduced to the level recommended by EPA.

The condenser associated with emission point 54-15 is another control device currently operating at Kodak Park which we feel can achieve a better removal efficiency. According to data provided by Kodak, this condenser has a removal efficiency of 50 percent.[5] From the yearly emission and flowrate data provided during the plant trip and assuming 24-hours a day year round operation, the concentration of DCM in the condenser's effluent would be approximately 37,242 ppm. Based on the removal efficiency provided by Kodak, the influent concentration to the condenser is estimated to be 74,485 ppm. The EPA's handbook for sizing control devices states that a properly sized condenser working with a influent concentration greater than 5,000 ppm should have a removal efficiency of 95 percent.[6] Alliance recommends that Kodak personnel make the proper adjustment in the condenser's operation so that a removal efficiency of 95 percent may be achieved. This increase in the removal efficiency would result in a reduction of DCM from this emission source of about 21,000 pounds per year.

The category 1 and 2 emission points which are remaining can be placed in the second group. These emission points can be characterized as uncontrolled fugitive emissions generated by various processes in the acetate film manufacturing loop and other areas. A list of these emission points is presented in Table 6-4 along with the concentration of DCM in each stream. These emission points emit approximately 785,249 pounds of DCM into the atmosphere per year. The emission points in this group are the ones to which add-on control technologies may be applied. There are some problems when applying a control device to many of these points. A majority of these points are associated with floor sweeps and ventilation of Buildings 52, 53 and 54. These emission points generally have large flowrates with low DCM concentrations. A list of emission points which fall into this category is presented in Table 6-5. One type of control device which can effectively control such low concentrations is a thermal incinerator. There are, however, problems associated with thermal incinerating of DCM. The first, as mentioned earlier, is the formation of HCl. A caustic scrubber can easily remove the HCl from the air flow but Kodak would then need to properly dispose of the scrubber's effluent. Another problem has to do with the amount of supplemental fuel in order to accomplish the incineration. Table 6-6 provides a list of

TABLE 6-4. FUGITIVE EMISSION SOURCES AT KODAK PARK

Source	Description	Flowrate, cfm	Actual Emissions, lbs/yr	Conc., ppm
52-37	BATCH MIXERS	1,110	193,680	1,531
53-K1	FLOOR SWEEPS FOR SOLVENT RECOVERY ROOM	22,000	110,000	44
53-88	FLOOR SWEEPS - DOPE DEPT.	34,400	86,724	22
53-08	FILTER PRESS CHANGING	15,000	75,680	44
54-29	FELT WASH PROCESS (5 FILTERS)	1	44,155	387,341
53-K2	EAST END FLOOR SWEEPS	9,000	36,500	36
21-12	KADY MILL EXHAUST	5,500	35,580	57
329K2	VESSEL CLEANING EXHAUST	4,100	27,450	59
D63-5	STEAMER CHARGING EXHAUST	3,550	26,280	65
53-96	STORAGE VESSEL VENTS	1	22,900	200,886
53-32	HOPPER CLEANING AND FLOOR SWEEPS	11,200	19,000	15
52-M2	WEST WALL EXHAUST FAN - 1ST FLOOR	6,000	17,800	26
53-92	SOLVENT DYE MIXING (FLOOR SWEEP SYSTEM)	12,000	15,000	11
52-M3	WEST WALL EXHAUST FAN - 2ND FLOOR	5,300	14,500	24
49-53	ULTRASONIC CLEANER	1,746	10,000	50

TABLE 6-5. EMISSIONS FROM VENTILATION SOURCES AT KODAK PARK

Source	Description	Flowrate, cfm	Actual Emissions, lbs/yr	Conc., ppm
52-37	BATCH MIXERS	1,110	193,680	1,531
53-K1	FLOOR SWEEPS FOR SOLVENT RECOVERY ROOM	22,000	110,000	44
53-88	FLOOR SWEEPS - DOPE DEPT.	34,400	86,724	22
53-08	FILTER PRESS CHANGING	15,000	75,680	44
53-K2	EAST END FLOOR SWEEPS	9,000	36,500	36
53-32	HOPPER CLEANING AND FLOOR SWEEPS	11,200	19,000	15
52-M2	WEST WALL EXHAUST FAN - 1ST FLOOR	6,000	17,800	26
53-92	SOLVENT DYE MIXING (FLOOR SWEEP SYSTEM)	12,000	15,000	11
52-M3	WEST WALL EXHAUST FAN - 2ND FLOOR	5,300	14,500	24

fuel costs for several emission points. The yearly expenditures for fuel shows that thermal incineration would be an expensive means of controlling DCM emissions. Recovery of DCM through a carbon adsorber from these emission points also presents a problems. The area of the carbon bed needed to provide an acceptable velocity through the bed would cause the carbon adsorber to be a rather large. The amount of DCM recovered from each of the points in question may not offset the cost of operating the recovery devices. A brief cost analysis for both types of control devices applied to a single source can be found in Appendix B. The cost estimates generated for this analysis are from a computer program, Controlling Air Toxics (CAT), developed for the CTC.

Another approach for a control strategy would be to combine emission streams to create a single source. A cost analysis of potential analysis of potential control devices for combined sources can be found in Appendix C. A control device of each type was proposed to reduce the emissions from Building 53 and 20. The emission sources under consideration for the Building 53 control device include the fugitive emission sources in Building 53 (see Table 6-4) and the emissions from the machine room exhaust. The only emission source under consideration for the Building 20 control device is the machine room exhaust.

Several of the points in this second group, however, present situations in which Kodak could recover DCM. The first situation involves the combining of emission points 52-37 (batch mixers) and 54-29 (felt wash process). As described earlier, the emissions from the emission point 54-29 occur when the filter elements from the felt wash process are being changed. Up to 5 gallons of DCM evaporates directly to the atmosphere for each change. A shroud could be fashioned to surround the immediate area around each felt wash canister during the changing procedure. A duct would be connected to the top of the shroud with sufficient flow to draw the DCM vapors toward it during the element changing. The flow from this duct would then be combined with the flow from the batch mixer ventilation system. The DCM then could be recovered by either a carbon adsorber or a dual scrubber system. The carbon adsorber for the recovery process could be the 4,000 cfm carbon adsorber currently being used to pressure balance the roll casting machines. This carbon adsorber will become available once the 18,000 cfm carbon adsorber replaces it. The flowrate of 4,000 cfm should be sufficient for both emission points. The cost to Kodak would be moving the carbon adsorber to a proper location, the duct work, and

TABLE 6-6. NATURAL GAS COST FOR THERMAL INCINERATION CONTROL DEVICE

Source	Description	Fuel Costs (June 1985 Dollars)
53-K1	FLOOR SWEEPS FOR SOLVENT RECOVERY ROOM	$ 1,565,802
53-88	FLOOR SWEEPS - DOPE DEPT.	$ 2,447,388
53-08	FILTER PRESS CHANGING	$ 1,067,991
53-K2	EAST END FLOOR SWEEPS	$ 640,356

operations. A dual scrubber system would also be an effective mean of recovering DCM from these combined emission points. Provided the scrubber is operated correctly, the advantage of using the dual scrubber is the small amount of space necessary to house it. If one assumes that the capture efficiency of the vents around the batch mixers and felt washer is 100 percent and that the carbon adsorber or scrubber operates at an efficiency of 90 percent, the reduction of DCM emissions from these two points would be 214,051 pounds per year.

Other points in this second group from which Kodak can easily control the emissions include points 53-32 (hopper cleaning and floor sweeps), 53-96 (storage vessel vents) and 49-53 (ultrasonic cleaner). During the plant visit, Kodak personnel indicated there were plans for connecting the vents surrounding the hopper cleaning baths to the 18,000 cfm carbon adsorber when it is installed. Such a move would greatly reduce the emissions from this point since the emissions would only consist of the floor sweeps being vented to the atmosphere. The storage vessel vents has an effluent concentration which can easily be handled by a recovery device. An easy means of reducing the emissions would be to connect the vent to the carbon adsorber in Building 53. Such a connection would only be a small fraction of the carbon adsorber's flowrate and the cost to Kodak would only be for the duct to connect the vent to the carbon adsorber. One could expect a reduction of 39,805 pounds of DCM per year if these points are included in the flows for the 18,000 cfm carbon adsorber. The ultrasonic cleaner (emission point 49-53) as described earlier, operates analogous to a degreasing operation. Controls for this source are described in Title 6, Chapter III, Part 226 of New York State's air pollution control regulations. Included are general requirements, equipment specifications, and operating requirements. Equipment specifications would include a cover when not in use, a freeboard ratio greater than or equal to 0.75, and use of either a refrigerated freeboard chiller, or carbon adsorber.

One emission point which proved difficult to assess a control technology for was the Kady Mill exhaust (point 21-21). The difficultly was not so much in analyzing a potential control device to reduce the emissions from this source, but in the data on the process provided by Kodak. During the plant visit, Kodak personnel stated that the Kady Mill was in operation for only two weeks out of the year. This means that the process emits 106 pounds of DCM per hour for it to have yearly DCM emissions of 35,580 pounds. Since the tank in

which the Kady Mill process takes place is only open during charging and cleaning, Alliance feels that this emissions estimate is rather high. Kodak needs to develop a better method of estimating the DCM emissions from this point other than a best engineering estimate. If the revised emissions estimate shows that the same amount of DCM is being lost to the atmosphere, then Kodak should decide whether to continue the Kady Mill process, given the large loss of DCM in a relatively short period of time.

Fugitive emissions from equipment and pipe lines in DCM service currently discharge 650,000 pounds of DCM per year into the environment. This amount represents approximately 8 percent of the total yearly DCM emissions at Kodak Park. This estimate is based on best engineering judgement, since Kodak has never counted the pumps, valves, flanges, seals, or open-ended lines in DCM service. At the present time, Kodak does not have a program to detect and repair leaks in this equipment on a regular basis. An option to reduce these emissions is the institution of a leak detection and repair (LDAR)[7] program for the equipment in DCM service. The recommended detection procedure for fugitive DCM emissions is EPA Reference Method 21.[8] This method incorporates the use of a portable analyzer to detect the presence of volatile organic vapors at the surface of the interface where direct leakage to the atmosphere can occur. This technique assumes that if a DCM leak exists, there will be an increased vapor concentration in the vicinity of the leak. By observing the changes in the concentration levels, the location and extent of the leak can then be determined. Once the severity of a leak has been defined, Kodak personnel could then take the appropriate actions for remediation of the emission source. At this time, Alliance is unable to estimate the amount of time necessary to complete a thorough inspection of all the potential fugitive emission sources. This is due to Kodak's inability to provide Alliance personnel with detailed information regarding the equipment type and number which are in DCM service. The cost for the LDAR program would come mostly from the man-hours required to perform the inspection for DCM leaks. The reduction in fugitive emissions resulting from the institution of the LDAR program can not be accurately determined at this time due to the same lack of detailed information. Generally speaking, a LDAR program has the potential of reducing fugitive emissions by 60 percent.[9] Once an LDAR program is in place, Kodak could expect fugitive DCM emission to be lowered by 390,000 pounds per year or a 4 percent reduction in overall emissions.

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APPENDIX A

Cellulose Triacetate Coated from Methylene Chloride
Solvent System

Docket # H-71 OSHA in response to 51FR42257
Submitted Feburary 19, 1987
by
R. Brothers - Director of Regulatory Affairs

Photographic Film Support

Cellulose Triacetate Coated From Methylene Chloride Solvent Systems

Eastman Kodak Company
February 1987

Cellulose triacetate is an essential ingredient of many of the photographic systems in use today. The unique properties of cellulose triacetate cannot be easily duplicated with other polymeric materials. This need for cellulose triacetate can best be appreciated by reviewing the requirements for photographic film supports.

Film Support Requirements

The requirements for a photographic film support are very exacting. Optically, it must be transparent, colorless, and free from haze and visible imperfections. Chemically, it must be stable over long periods of time, inert to highly sensitive emulsions, and allow for proper adhesion of the emulsion layers. A low volatile content to prevent dimensional change on processing and storage is also necessary. Physical requirements include strength and toughness, hardness without brittleness, stiffness with flexibility, tear resistance, and freedom from curl. Thermally, a film support must have a high softening temperature and be slow burning.[1]

In addition to these general requirements, there are special needs in each product area. For example, successful operation of photographic equipment for 35mm, 110, and 126 amateur roll films and 8mm and Super 8 amateur movie films requires a support material which will retain the curvature of the core on which the film is wound during manufacture. This retained curvature must then be removed during photographic processing to yield film negatives for printing which are nearly flat and to allow the proper curvature for automatic threading to be induced in movie films. For the professional motion picture market, camera original, laboratory intermediate, and release films require a strong, tough support with good wearing qualities. Many graphic arts applications require a film which can be easily cut into sections for the preparation of advertising layouts.

Film Supports

The above requirements are so rigid that relatively few materials have proved to be practical as supports for photographic films. The physical properties of various cellulose film support materials are listed in Table 1.[2,3] The first flexible film support, introduced in 1889, was manufactured from cellulose nitrate. It had excellent physical properties, but suffered from poor chemical stability and was a severe fire hazard because of its explosive nature and the toxicity of its fumes.

In 1922, amateur film was introduced on cellulose diacetate support because its slow burning feature was considered essential for this product. Mixed esters of cellulose acetate butyrate or cellulose acetate propionate possessed improved physical properties and gradually replaced cellulose diacetate starting around 1940. However, none of these materials had the strength, toughness, and heat resistance required for professional motion picture films. These products remained on cellulose nitrate support.

Cellulose triacetate, although it will support combustion like most organic polymers, is considerably less flammable. To further enhance this property, flame retardant plasticizers have been an integral component of cellulose triacetate film support since its inception. The major obstacle to development and use of cellulose triacetate film supports was its extremely limited solubility.

Ethylene dichloride and propylene dichloride were initially used as principal film support casting solvents but concerns over the toxicity of these solvents prompted a search for a less toxic, more volatile solvent. Methylene chloride uniquely meets these requirements. Not only is it an essentially nonflammable solvent with a low order of chemical reactivity, but its fast evaporation rate provides a cost efficient method of producing film support at reasonable speeds. It may also be efficiently recovered for reuse.

The introduction of cellulose triacetate film base in the 1940's provided for the first time a slow-burning support for motion-picture film use, permitting the manufacture of cellulose nitrate to be discontinued. Cellulose triacetate eventually became the support of choice for roll and amateur movie films and those sheet films requiring ease of cutting.[1,4,10]

Polyethylene terephthalate, which became available as a film support about 1955, is very moisture resistant as compared with the cellulosic supports, and also has higher strength, stiffness, and tear resistance. (See Table 2).[5,6,7,8] Polyethylene terephthalate is used in sheet films, aerial films and industrial films. It has not been used extensively, however, in the amateur roll and movie film areas because of its low plastic flow and high moisture resistance. Professional motion picture films are currently available on polyethylene terephthalate, but these products have not been widely used in the trade. Most motion picture film is manufactured on cellulose triacetate so that solvent splices may be made. Also, many graphic arts film users prefer cellulose triacetate because of its ease of cutting.

Since the advent of cellulose triacetate and polyethylene terephthalate, no new film support has come into widespread use in the photographic industry.

Cellulose Triacetate

Cellulose triacetate is ideally suited for the amateur roll and movie film areas because of its plastic flow characteristics. Core set represents an important manifestation of plastic flow in photographic systems because films are normally available as rolls wound on cores. When a film is held in such a curved configuration, plastic flow occurs and the support retains a portion of the curvature of the core on which it was wound. This is called "core set". Figure 1[8] illustrates this core set, with the degree of curvature measured in ANSI curl units (100 divided by the radius of curvature in inches) so that higher numbers mean greater curvature.[7,9]

Most of the amateur photographic equipment in use today, including cameras, projectors, magazines, and cartridges, has been designed for the core set characteristics of cellulose triacetate. The transport mechanisms and exposure assemblies for all of these devices usually require a curvature similar to that of cellulose triacetate films for best performance. Use of film support material with core set characteristics significantly different from those of cellulose triacetate will result in decreased reliability and possible inoperability for many consumer cameras and projectors and for photographic processing equipment.

Absorption of water in aqueous processing solutions by cellulose triacetate enables its plastic flow or core set to relax, so that films on this support are relatively flat after processing. Many films, such as 35mm, 110, and 126 formats, require flat negatives to facilitate the making of photographic prints and to avoid bulky customer shipping envelopes. Removal of core set in processing solutions is also important for many amateur movie film projectors in which automatic threading depends upon the film core set being removed in processing and core set being induced in the opposite direction by storage on processed film reels. With this core set configuration, the unsupported film naturally takes a path which leads into the threading mechanism.

Film Support Manufacturing

To better understand the requirements of a film support casting solvent, a brief overview of the solution making and casting procedures is necessary. Cellulose triacetate is combined with methylene chloride, plasticizers and minor amounts of co-solvents and mixed with heat to produce a viscous concentrated polymer solution or dope. The dope is then filtered to remove any impurities, further concentrated and cast onto a polished metal surface. When sufficient solvent has evaporated to allow the film to be self-supporting, it is stripped off the metal surface and conveyed into dryers. The evaporated solvents are condensed, purified and recycled to the dope-making stage.

Solubility of Cellulose Triacetate

The solubility of a polymer is dependent upon its molecular weight, the degree and nature of substitution in the polymer chain, and its degree of crystallinity. The influence of these properties is quite evident for cellulose and its derivatives. Pure cellulose is reported to be soluble only in solutions such as Schweitzer's reagent (copper hydroxide in ammonia) or zinc chloride, which are capable of forming complexes with it.[11] The insolubility of cellulose in common organic solvents is attributed to its crystallinity and intermolecular hydrogen bonding.

The solubility of cellulose acetate esters is further dependent upon the degree of acetylation (or the degree of hydrolysis). Far-hydrolyzed cellulose acetate (18-26% acetic acid content) can be made water-soluble. The original inherent crystallinity is largely destroyed and the presence of many hydroxyl groups allow solvation.

Increasing the acetyl content to a range corresponding to the diacetate (44-52% acetic acid) decreases the water solubility, since the number of hydroxyl groups decreases, and the polymer now becomes soluble in ketone and ester type solvents. At this point the cellulose acetate molecules exhibit characteristics of both Lewis acids and bases and hence are soluble in both acidic and basic solvents. An almost fully acetylated triacetate (61-63% acetic acid content), such as that required for photographic film support, is reported by one source to be soluble only in acid type solvents capable of forming hydrogen bonds.[11]

A method useful in predicting the solubility of polymers, particularly cellulosics, was introduced in 1966 by James D. Crowley and colleagues of Eastman Chemical Products, Inc.[12] His concepts have gained wide commercial acceptance and have been utilized during the last twenty years to characterize the solubility of cellulose derivatives and predict potential alternate solvents. In essence, his work identified three parameters which can be used to uniquely characterize solvents. These are the solubility parameter, hydrogen bonding and dipole moment. Using the solubility law of "like dissolves like," these three parameters or ranges can also be assigned to solutes.

Using a modification of the ASTM D3132 test procedure for determining polymer solubility ranges, the profile of cellulose triacetate has been empirically determined to be:

Solubility Parameter (δ): 9.7-11.1
Hydrogen Bonding (γ): 1.5-6.3
Dipole Moment (μ): 1.4-1.6

Table 3 lists (by increasing δ) the known, and many predicted solvents for cellulose triacetate. It is apparent that, among the solvents listed, there exist anomolies even using Crowley's three-dimensional approach.

Many of the compounds referred to in the literature[11,13] as being solvents for cellulose triacetate do not have practical or commercial value due to their relatively poor solvent characteristics or toxicity. The substances evaluated as potentially practical solvents for cellulose triacetate have been relisted in Table 4 (by increasing boiling point). Also included are the evaporation rates relative to methylene chloride and flash points which offer a guide to their utility as the major constituent in a casting formulation.

N-Methyl-2-pyrrolidone, with a boiling point exceeding 200°C, is not a practical primary casting solvent. Its use would need to be restricted to less than 10% of the solvent formulation to allow a film to be stripped from the metal surface. It is also unlikely that residual solvent could be reduced to a level whereby the film would meet established physical requirements.

Dioxane and dioxolane, in addition to being flammable and explosive, also have a tendency to form explosive peroxides and the volumes required for the manufacture of film support would present extreme safety risks.

The use of 2,3-butanedione, also flammable and explosive, as a primary casting solvent would have a major impact on manufacturing efficiency. Having an evaporation rate which is less than half that of methylene chloride would mean that the casting, stripping and drying operations would be restricted to half the speed. In addition, this solvent has an inherent yellow color which remains in the film support even after drying two hours at 150°C, making it impractical for producing a clear, transparent support.

Conclusions

Cellulose triacetate is essential to the photographic industry because many current photographic systems have been designed to take advantage of the unique plastic flow and moisture absorption characteristics of this material. These characteristics are not duplicated by other available polymeric materials, including cellulose diacetate and mixed cellulose esters. Methylene chloride is necessary for cellulose triacetate film support production because no other safe practical coating solvent is available.

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APPENDIX B

CAT Analysis of Emission Points

Emission Point		Page
53-K1	Using Thermal Incineration	B-2
53-K1	Using Carbon Adsorption	B-5
53-K2	Using Thermal Incineration	B-9
53-K2	Using Carbon Adsorption	B-13
53-08	Using Thermal Incineration	B-17
53-08	Using Carbon Adsorption	B-21
53-88	Using Thermal Incineration	B-25
53-88	Using Carbon Adsorption	B-29

CAT Analysis of Emission Point
53-K1 Using Thermal Incineration

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation Checked
Maximum flow rate (scfm)	22000	22000
Pressure (mmHg)		760
Temperature (degF)	72	72
Heat content (Btu/scf)		1
Oxygen content (%)		21
Moisture content (%)		5
Relative humidity (%)	50	50
Are halogenated organics present? (Y/N)	Y	Y
Are metals present? (Y/N)	N	N

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation Checked
Inlet HAP concentration (ppmv)	43.8821	43.8821
Molecular weight (lb/lb-mole)		84.93
Specific heat equation constant A		
Specific heat equation constant B		
Specific heat equation constant C		
Antoine equation constant A		
Antoine equation constant B		
Antoine equation constant C		
Heat of vaporization (Btu/lb-mole)		

	Applicant	Calculation Checked
DESIGN RELATED PARAMETERS.....		
Destruction efficiency (%)		99
Combustion temperature (degF)		1800
Residence time (sec)		2
Is a heat exchanger used? (Y/N)		Y
Emission stream temp. after preheat (degF)		600
Excess air (%)		25
Area to Qe ratio		1
Heating value of supplement. fuel (Btu/scf)		882
Reference temperature (degF)		70

COST RELATED PARAMETERS.....

Duct cost ($/linear ft)	15
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Review of Thermal Incinerator:

METHYLENE CHLORIDE:

The HAP inlet concentration is too low for a high destruction efficiency.

If the HAP concentration in the emission stream exceeds 25% of the lower explosive limit, then dilution of the emission stream will be required.

This device is not well suited to emission streams with highly variable flow rates.

Intermediate Results:

Cpair(600) = 0.0185
Cpair(1800) = 0.0203
Qc = 0
deltaTLM = 1200

Permit Evaluation:

Supplementary heat requirement (Btu/min)	629710
Supplementary fuel flow rate (scfm)	714
Flue gas flow rate (scfm)	22714
Combustion chamber volume (ft3)	3390
Heat exchanger surface area (ft2)	2711

Total Capital Investment (June 1985 Dollars):

348475

Direct Operating Costs

Natural Gas	1565802
Electricity	58974
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197

Indirect Operating Costs

Overhead	10659
Property Tax	3485
Insurance	3485
Administrative	6970
Capital Recovery	56801

Net Annualized Cost (June 1985 Dollars):

1725697

CAT Analysis of Emission Point
53-K1 Using Carbon Adsorption

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation Checked
Maximum flow rate (scfm)	22000	22000
Pressure (mmHg)		
Temperature (degF)	72	72
Heat content (Btu/scf)		
Oxygen content (%)		
Moisture content (%)		
Relative humidity (%)	50	50
Are halogenated organics present? (Y/N)	Y	Y
Are metals present? (Y/N)	N	N

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation Checked
Inlet HAP concentration (ppmv)	43.8821	43.8821
Molecular weight (lb/lb-mole)		84.93
Specific heat equation constant A		
Specific heat equation constant B		
Specific heat equation constant C		
Antoine equation constant A		
Antoine equation constant B		
Antoine equation constant C		
Heat of vaporization (Btu/lb-mole)		

DESIGN RELATED PARAMETERS.....	Applicant	Calculation Checked
Removal efficiency (%)		90
Adsorptive capacity (lb HAP/100 lb carbon)		3
Number of beds		3
Cycle time for adsorption (hr)		4
Cycle time for regeneration (hr)		3.5
Stream velocity through the bed (ft/min)	65	65
Steam ratio (lb steam/lb carbon)	0.4	0.4
Steam inlet temperature (degF)		212
Condensed steam outlet temperature (degF)		100
Cooling water inlet temperature (degF)		50
Cooling water outlet temperature (degF)		100
Carbon bed density (lb/ft3)		30
Cycle time for drying and cooling (hr)		.5
Latent heat of vaporization (Btu/lb)		970
Avg. specific heat of water (Btu/lb-degF)		1
Overall heat trans coef (Btu/hr-ft2-degF)		150

COST RELATED PARAMETERS.....		
Value of recovered product ($/lb)	.2	.2
Duct cost ($/linear ft)	15	15
Stack capital cost ($)	20000	20000
Length of duct (ft)	150	150
Total pressure drop (in. H2O)		6
Average equipment life (yr)		10
Operator labor requirements (hr/shift)		.5
Maintenance labor requirements (hr/shift)		.5

Intermediate Results for METHYLENE CHLORIDE:

HAPo =	4.39
Abed =	340
Vcarbon =	102
Hload =	1.45E+006
deltaTLM =	76.9
Qfg =	2.2E+004

Permit Evaluation:

Carbon requirement (lb)	9150
Bed diameter (ft)	21
Bed depth (ft)	0
Steam flow rate (lb/min)	20
Condenser surface area (ft2)	126
Cooling water rate (gal/min)	58
Recovered product (lb/hr)	11

Total Capital Investment (June 1985 Dollars):

92151

Direct Operating Costs

Electricity	13446
Steam	52013
Water	8978
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197
Replacement Labor	3514
Replacement Parts	3514

Indirect Operating Costs

Overhead	13470
Property Tax	922
Insurance	922
Administrative	1843
Capital Recovery	15021

Credits

Sale of Product 2

Net Annualized Cost (June 1985 Dollars):

133161

CAT Analysis of Emission Point
53-K2 Using Thermal Incineration

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation Checked
Maximum flow rate (scfm)	9000	9000
Pressure (mmHg)		760
Temperature (degF)		72
Heat content (Btu/scf)		1
Oxygen content (%)		21
Moisture content (%)		5
Relative humidity (%)		50
Are halogenated organics present? (Y/N)	Y	Y
Are metals present? (Y/N)	N	N

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation Checked
Inlet HAP concentration (ppmv)		35.5932
Molecular weight (lb/lb-mole)		84.93
Specific heat equation constant A		
Specific heat equation constant B		
Specific heat equation constant C		
Antoine equation constant A		
Antoine equation constant B		
Antoine equation constant C		
Heat of vaporization (Btu/lb-mole)		

	Applicant	Calculation Checked
DESIGN RELATED PARAMETERS.....		
Destruction efficiency (%)		99
Combustion temperature (degF)		1800
Residence time (sec)		2
Is a heat exchanger used? (Y/N)		Y
Emission stream temp. after preheat (degF)		600
Excess air (%)		25
Area to Qe ratio		
Heating value of supplement. fuel (Btu/scf)		882
Reference temperature (degF)		70

COST RELATED PARAMETERS.....

Duct cost ($/linear ft)	15
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Review of Thermal Incinerator:

METHYLENE CHLORIDE:

The HAP inlet concentration is too low for a high destruction efficiency.

If the HAP concentration in the emission stream exceeds 25% of the lower explosive limit, then dilution of the emission stream will be required.

This device is not well suited to emission streams with highly variable flow rates.

Intermediate Results:

Cpair(600) = 0.0185
Cpair(1800) = 0.0203
Qc = 0
deltaTLM = 1200

Permit Evaluation:

Supplementary heat requirement (Btu/min)	257608
Supplementary fuel flow rate (scfm)	292
Flue gas flow rate (scfm)	9292
Combustion chamber volume (ft3)	1387
Heat exchanger surface area (ft2)	1109

Total Capital Investment (June 1985 Dollars):

246853

Direct Operating Costs

Natural Gas	640356
Electricity	24125
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197

Indirect Operating Costs

Overhead	10659
Property Tax	2469
Insurance	2469
Administrative	4937
Capital Recovery	40237

Net Annualized Cost (June 1985 Dollars):

744774

CAT Analysis of Emission Point
53-K2 Using Carbon Adsorption

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation Checked
Maximum flow rate (scfm)	9000	9000
Pressure (mmHg)		
Temperature (degF)		72
Heat content (Btu/scf)		
Oxygen content (%)		
Moisture content (%)		
Relative humidity (%)		50
Are halogenated organics present? (Y/N)	Y	Y
Are metals present? (Y/N)	N	N

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation Checked
Inlet HAP concentration (ppmv)		35.5932
Molecular weight (lb/lb-mole)		84.93
Specific heat equation constant A		
Specific heat equation constant B		
Specific heat equation constant C		
Antoine equation constant A		
Antoine equation constant B		
Antoine equation constant C		
Heat of vaporization (Btu/lb-mole)		

DESIGN RELATED PARAMETERS.....	Applicant	Calculation Checked
Removal efficiency (%)		90
Adsorptive capacity (lb HAP/100 lb carbon)	3	3
Number of beds		2
Cycle time for adsorption (hr)		4
Cycle time for regeneration (hr)		3.5
Stream velocity through the bed (ft/min)	65	65
Steam ratio (lb steam/lb carbon)	.4	.4
Steam inlet temperature (degF)		212
Condensed steam outlet temperature (degF)		100
Cooling water inlet temperature (degF)		50
Cooling water outlet temperature (degF)		100
Carbon bed density (lb/ft3)		30
Cycle time for drying and cooling (hr)		.5
Latent heat of vaporization (Btu/lb)		970
Avg. specific heat of water (Btu/lb-degF)		1
Overall heat trans coef (Btu/hr-ft2-degF)		150

COST RELATED PARAMETERS.....

Value of recovered product ($/lb)	.2
Duct cost ($/linear ft)	15
Stack capital cost ($)	20000
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Intermediate Results for METHYLENE CHLORIDE:

HAPo =	3.56
Abed =	139
Vcarbon =	33.7
Hload =	3.21E+005
deltaTLM =	76.9
Qfg =	9000

Permit Evaluation:

Carbon requirement (lb)	2024
Bed diameter (ft)	13
Bed depth (ft)	0
Steam flow rate (lb/min)	4
Condenser surface area (ft2)	28
Cooling water rate (gal/min)	13
Recovered product (lb/hr)	4

Total Capital Investment (June 1985 Dollars):

44622

Direct Operating Costs

Electricity	5501
Steam	10403
Water	2012
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197
Replacement Labor	777
Replacement Parts	777

Indirect Operating Costs

Overhead	11281
Property Tax	446
Insurance	446
Administrative	892
Capital Recovery	7273

Credits

Sale of Product	1

Net Annualized Cost (June 1985 Dollars):

59330

CAT Analysis of Emission Point
53-08 Using Thermal Incineration

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation	Checked
Maximum flow rate (scfm)	15000	15000	
Pressure (mmHg)		760	
Temperature (degF)		72	
Heat content (Btu/scf)		1	
Oxygen content (%)		21	
Moisture content (%)		5	
Relative humidity (%)		50	
Are halogenated organics present? (Y/N)	Y	Y	
Are metals present? (Y/N)	N	N	

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation	Checked
Inlet HAP concentration (ppmv)		44.2799	
Molecular weight (lb/lb-mole)		84.93	
Specific heat equation constant A			
Specific heat equation constant B			
Specific heat equation constant C			
Antoine equation constant A			
Antoine equation constant B			
Antoine equation constant C			
Heat of vaporization (Btu/lb-mole)			

	Applicant	Calculation	Checked
DESIGN RELATED PARAMETERS.....			
Destruction efficiency (%)		99	
Combustion temperature (degF)		1800	
Residence time (sec)		2	
Is a heat exchanger used? (Y/N)		Y	
Emission stream temp. after preheat (degF)		600	
Excess air (%)		25	
Area to Qe ratio			
Heating value of supplement. fuel (Btu/scf)		882	
Reference temperature (degF)		70	

COST RELATED PARAMETERS.....

Duct cost ($/linear ft)	15
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Review of Thermal Incinerator:

METHYLENE CHLORIDE:

The HAP inlet concentration is too low for a high destruction efficiency.

If the HAP concentration in the emission stream exceeds 25% of the lower explosive limit, then dilution of the emission stream will be required.

This device is not well suited to emission streams with highly variable flow rates.

Intermediate Results:

Cpair(600) = 0.0185
Cpair(1800) = 0.0203
Qc = 0
deltaTLM = 1200

Permit Evaluation:

Supplementary heat requirement (Btu/min)	429347
Supplementary fuel flow rate (scfm)	487
Flue gas flow rate (scfm)	15487
Combustion chamber volume (ft3)	2311
Heat exchanger surface area (ft2)	1849

Total Capital Investment (June 1985 Dollars):

295667

Direct Operating Costs

Natural Gas	1067991
Electricity	40210
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197

Indirect Operating Costs

Overhead	10659
Property Tax	2957
Insurance	2957
Administrative	5913
Capital Recovery	48194

Net Annualized Cost (June 1985 Dollars):

1198402

CAT Analysis of Emission Point
53-08 Using Carbon Adsorption

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation Checked
Maximum flow rate (scfm)	15000	15000
Pressure (mmHg)		
Temperature (degF)		72
Heat content (Btu/scf)		
Oxygen content (%)		
Moisture content (%)		
Relative humidity (%)		50
Are halogenated organics present? (Y/N)	Y	Y
Are metals present? (Y/N)	N	N

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation Checked
Inlet HAP concentration (ppmv)		44.2799
Molecular weight (lb/lb-mole)		84.93
Specific heat equation constant A		
Specific heat equation constant B		
Specific heat equation constant C		
Antoine equation constant A		
Antoine equation constant B		
Antoine equation constant C		
Heat of vaporization (Btu/lb-mole)		

	Applicant	Calculation Checked
DESIGN RELATED PARAMETERS.....		
Removal efficiency (%)		90
Adsorptive capacity (lb HAP/100 lb carbon)	3	3
Number of beds		2
Cycle time for adsorption (hr)		4
Cycle time for regeneration (hr)		3.5
Stream velocity through the bed (ft/min)	65	65
Steam ratio (lb steam/lb carbon)	.4	.4
Steam inlet temperature (degF)		212
Condensed steam outlet temperature (degF)		100
Cooling water inlet temperature (degF)		50
Cooling water outlet temperature (degF)		100
Carbon bed density (lb/ft3)		30
Cycle time for drying and cooling (hr)		.5
Latent heat of vaporization (Btu/lb)		970
Avg. specific heat of water (Btu/lb-degF)		1
Overall heat trans coef (Btu/hr-ft2-degF)		150

COST RELATED PARAMETERS.....

Value of recovered product ($/lb)	.2
Duct cost ($/linear ft)	15
Stack capital cost ($)	20000
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Intermediate Results for METHYLENE CHLORIDE:

HAPo = 4.43
Abed = 232
Vcarbon = 69.9
Hload = 6.66E+005
deltaTLM = 76.9
Qfg = 1.5E+004

Permit Evaluation:

Carbon requirement (lb)	4197
Bed diameter (ft)	17
Bed depth (ft)	0
Steam flow rate (lb/min)	9
Condenser surface area (ft2)	58
Cooling water rate (gal/min)	27
Recovered product (lb/hr)	8

Total Capital Investment (June 1985 Dollars):

59724

Direct Operating Costs

Electricity	9168
Steam	23406
Water	4180
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197
Replacement Labor	1612
Replacement Parts	1612

Indirect Operating Costs

Overhead	11949
Property Tax	597
Insurance	597
Administrative	1194
Capital Recovery	9735

Credits

Sale of Product	2

Net Annualized Cost (June 1985 Dollars):

83569

CAT Analysis of Emission Point
53-88 Using Thermal Incineration

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation	Checked
Maximum flow rate (scfm)	34400	34400	
Pressure (mmHg)		760	
Temperature (degF)		72	
Heat content (Btu/scf)		1	
Oxygen content (%)		21	
Moisture content (%)		5	
Relative humidity (%)		50	
Are halogenated organics present? (Y/N)	Y	Y	
Are metals present? (Y/N)	N	N	

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation	Checked
Inlet HAP concentration (ppmv)		22.1257	
Molecular weight (lb/lb-mole)		84.93	
Specific heat equation constant A			
Specific heat equation constant B			
Specific heat equation constant C			
Antoine equation constant A			
Antoine equation constant B			
Antoine equation constant C			
Heat of vaporization (Btu/lb-mole)			

	Applicant	Calculation	Checked
DESIGN RELATED PARAMETERS.....			
Destruction efficiency (%)		99	
Combustion temperature (degF)		1800	
Residence time (sec)		2	
Is a heat exchanger used? (Y/N)		Y	
Emission stream temp. after preheat (degF)		600	
Excess air (%)		25	
Area to Qe ratio		1	
Heating value of supplement. fuel (Btu/scf)		882	
Reference temperature (degF)		70	

COST RELATED PARAMETERS.....

Duct cost ($/linear ft)	15
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Review of Thermal Incinerator:

METHYLENE CHLORIDE:

The HAP inlet concentration is too low for a high destruction efficiency.

If the HAP concentration in the emission stream exceeds 25% of the lower explosive limit, then dilution of the emission stream will be required.

This device is not well suited to emission streams with highly variable flow rates.

Intermediate Results:

Cpair(600) = 0.0185
Cpair(1800) = 0.0203
Qc = 0
deltaTLM = 1200

Permit Evaluation:

Supplementary heat requirement (Btu/min)	984637
Supplementary fuel flow rate (scfm)	1116
Flue gas flow rate (scfm)	35516
Combustion chamber volume (ft3)	5301
Heat exchanger surface area (ft2)	4240

Total Capital Investment (June 1985 Dollars):

435725

Direct Operating Costs

Natural Gas	2447388
Electricity	92212
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197

Indirect Operating Costs

Overhead	10659
Property Tax	4357
Insurance	4357
Administrative	8715
Capital Recovery	71023

Net Annualized Cost (June 1985 Dollars):

2658234

CAT Analysis of Emission Point
53-88 Using Carbon Adsorption

Plant:

Eastman Kodak Company
1669 Lake Avenue
Rochester, NY 14652-4201

Contact: Jeffery Mathews, P.E.
Phone: (716) 722-0692 Ext.

Agency contact:

Emission Stream:

	Applicant	Calculation	Checked
Maximum flow rate (scfm)	34400	34400	
Pressure (mmHg)			
Temperature (degF)		72	
Heat content (Btu/scf)			
Oxygen content (%)			
Moisture content (%)			
Relative humidity (%)		50	
Are halogenated organics present? (Y/N)	Y	Y	
Are metals present? (Y/N)	N	N	

Hazardous Air Pollutant: 75-09-2 METHYLENE CHLORIDE

	Applicant	Calculation	Checked
Inlet HAP concentration (ppmv)		22.1257	
Molecular weight (lb/lb-mole)		84.93	
Specific heat equation constant A			
Specific heat equation constant B			
Specific heat equation constant C			
Antoine equation constant A			
Antoine equation constant B			
Antoine equation constant C			
Heat of vaporization (Btu/lb-mole)			

	Applicant	Calculation	Checked
DESIGN RELATED PARAMETERS.....			
Removal efficiency (%)		90	
Adsorptive capacity (lb HAP/100 lb carbon)	3	3	
Number of beds		3	
Cycle time for adsorption (hr)		4	
Cycle time for regeneration (hr)		3.5	
Stream velocity through the bed (ft/min)	65	40	
Steam ratio (lb steam/lb carbon)	.4	.4	
Steam inlet temperature (degF)		212	
Condensed steam outlet temperature (degF)		100	
Cooling water inlet temperature (degF)		50	
Cooling water outlet temperature (degF)		100	
Carbon bed density (lb/ft3)		30	
Cycle time for drying and cooling (hr)		.5	
Latent heat of vaporization (Btu/lb)		970	
Avg. specific heat of water (Btu/lb-degF)		1	
Overall heat trans coef (Btu/hr-ft2-degF)		150	

COST RELATED PARAMETERS.....

Value of recovered product ($/lb)	.2
Duct cost ($/linear ft)	15
Stack capital cost ($)	20000
Length of duct (ft)	150
Total pressure drop (in. H2O)	6
Average equipment life (yr)	10
Operator labor requirements (hr/shift)	.5
Maintenance labor requirements (hr/shift)	.5

Intermediate Results for METHYLENE CHLORIDE:

HAPo =	2.21
Abed =	863
Vcarbon =	80.2
Hload =	1.14E+006
deltaTLM =	76.9
Qfg =	3.44E+004

Permit Evaluation:

Carbon requirement (lb)	7214
Bed diameter (ft)	33
Bed depth (ft)	0
Steam flow rate (lb/min)	16
Condenser surface area (ft2)	99
Cooling water rate (gal/min)	46
Recovered product (lb/hr)	9

Total Capital Investment (June 1985 Dollars):

103251

Direct Operating Costs

Electricity	21025
Steam	41610
Water	7121
Operator Labor	6197
Operator Supervision	930
Maintenance Labor	6197
Maintenance Materials	6197
Replacement Labor	2770
Replacement Parts	2770

Indirect Operating Costs

Overhead	12876
Property Tax	1033
Insurance	1033
Administrative	2065
Capital Recovery	16830

Credits

Sale of Product	2

Net Annualized Cost (June 1985 Dollars):

128651

APPENDIX C

Development of Costs for Using Control Devices for
Vents from Buildings 53 and 20
Supplemental Task to Work Assignment No. 13
Contract No. 68-02-4396

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INTRODUCTION

As part of this work assignment, Alliance was asked to develop a more detailed cost analysis for a control device to reduce the methylene chloride (dichloromethane or DCM) emissions from Building 53 and 20. This will be an addendum to the original report issued under this work assignment.

The two control devices under consideration in this analysis:
Carbon Adsorber System
Thermal Incineration System

The emission points under consideration in Building 53 (1987 emission data):

Point ID/Description	Flowrate (cfm)	Emissions (lbs/yr)
53-85 Existing Machine Room Exhaust	250,000	4,700,000
53-38 Existing Machine Room Exhaust	125,000	1,300,000
53-K1 Floor Sweeps for Solvent Recovery Room	20,000	150,000
53-88 Floor Sweeps - Dope Department	34,400	86,724
53-08 Filter Press Changing	15,000	75,680
53-K2 East End Floor Sweeps	9,000	36,500
53-96 Storage Vessel Vents	1	22,900
53-32 Hopper Cleaning and Floor Sweeps	11,200	19,000
53-92 Solvent Dye Mixing (Floor Sweeps System)	12,000	15,000
Total	476,600	6,405,805

These emission points are vented through the roof of Building 53 and thus can be combined for common control device. This analysis will treat these 9 emission sources as a single stream with a flowrate of 500,000 cfm and 6,400,000 pounds of yearly DCM emissions. It should be noted that one category 2 emission source in Building 53 was omitted from the list of points under consideration. This point, 53-22, is the exhaust from the carbon adsorber for the machine air draw-off. Placing a secondary control device for the same compound on a emission source from a control device is rarely cost effective and does not represent sound engineering practices.

The emission point under consideration in Building 20 (1987 emissions data)

Point ID/Description	Flowrate (cfm)	Emissions (lbs/yr)
20-68 Existing Machine Room Exhaust	150,000	1,380,000

Kodak is currently undertaking an emission reduction program in its acetate film base manufacturing loop. The main program of this effort will be the machine integrity program. The focus of this program will be to modify the machine casings to improve the "seal quality." Kodak has a target reduction of DCM emissions due to this program of 3,000,000 pounds per year. Kodak personnel anticipate the completion of this program by 1990. For the purpose of this task, we will assume that Kodak completes the emission reduction program on time and achieves the targeted DCM emission reduction. The next problem would be how to assign the anticipated emissions reduction to each film base casting room. A simple solution would be to assume that the amount of

emissions reduction in each machine room is related to the percent each machine room contributes to the total emissions caused by the casting machines. From the 1987 data, the total emissions caused by the film base casting machines were 7,380,000 pounds per year. The machine room in Building 53 accounted for 6,000,000 pounds or 81.3 percent while the machine room in Building 20 emitted 1,380,000 pounds or 18.7 percent. Using these percentages to assign the amount of DCM emissions reduced, the emissions from Building 53 machine room can be expected to be lowered by 2,439,000 pounds and the emissions from Building 20 machine room would be decreased by 561,000 pounds. Thus, the yearly emissions expected from Building 53 are 4,000,000 pounds and from Building 20 machine room 819,000 pounds of emissions would be expected each year.

One of the parameters which characterizes the emission stream is the flowrate. The flowrate will govern how big a control device is required. The greater the flowrate, the larger the control device will be needed to handle the flow. The flowrate also determine the concentration of the compound in the stream. According to the 1987 data from Kodak, the total flowrate from the category 1 and 2 emission sources in Building 53 was approximately 500,000 cfm. The flowrate from the film base casting machine room in Building 20 was 150,000 cfm.

The concentration of DCM in the emission stream was determined in the same manner as in Section 6 (see Table 6-3). Using the yearly emissions estimate and flowrate discussed previously, the DCM concentration in the combined emission stream from Building 53 was determined to be approximately 70 ppm. The concentration of DCM in machine room vent flows from Building 20 was calculated to be 48 ppm.

Other characteristics of the emission streams which will be assumed for this analysis:

- the temperature is a consistent 100 ^{o}F
- the relative humidity is less than 50 percent
- the moisture content is 5 percent
- the oxygen content is 21 percent
- other chemical compounds present will not have any discernable effect of the control device's ability to reduce the stream's DCM emissions.

CONTROL DEVICES

Carbon Adsorber

Alliance personnel contacted several manufactures of carbon adsorbers seeking information concerning the purchase cost of a system for each stream. One manufacturer stated that for the flowrates in question, anticipate a carbon adsorber system costing $14 per cfm.[1] This would mean that the purchase cost of a carbon adsorber for Building 53 would $7,000,000 and one for Building 20 would cost $2,100,000. Alliance personnel contact with another carbon adsorber manufacturer confirmed these purchase costs.[2] The carbon adsorbers would be constructed using 904 stainless steel for the tanks and associated equipment. The recovery efficiency of the carbon adsorber system would be 90 to 95 percent for single pass air. One manufacturer stated that this efficiency could be improved to the high 90's if at least half the air

could be recycled.[1] The determination of annual costs for each carbon adsorber for each stream is as follows using factors and utilities costs from the EPA Handbook: Control Technologies for Hazardous Air Pollutants:[3]

Building 53 Carbon Adsorber

Purchase Cost for a 500,000 cfm flowrate at $14/cfm
500,000 x 14 = $7,000,000.

Total Capital expenditure (factoring in other direct costs and indirect costs)
$7,000,000 x 1.63 = $11,410,000.

Assume the recovery efficiency of the carbon adsorber system is 90 percent. Thus, from emissions of 4,000,000 lbs/yr, 3,600,000 lbs/yr will be recovered.

Utilities Required

Steam required (Assume 4 lbs of steam required for each lb of product recovered.)
4 x 3,600,000 = 14,400,000 lbs of steam/year.

Cooling water required (Assume 12 gallons of cooling water required per 100 lbs of steam.)
12 x (14,400,000/100) = 1,728,000 gals of water/year.

Fan electricity required (Assume a fan efficiency of 65 percent and a pressure drop of 7 in. H_2O across the control system.)

2.0×10^{-4} x Flowrate x Press. Drop x Hrs =
Electricity required per year (kWh)

2.0×10^{-4} x 500,000 x 7 x 8760 = 6,132,000 kWh/year.

Utilities Cost (June 1985 dollars)

Steam cost (Based on $0.00504 per lb.)
14,400,000 x 0.00504 = $72,576/year.

Water cost (Based on $0.0003 per gallon.)
1,728,000 x 0.0003 = $518/yr.

Electricity cost (Based on $0,059 per kWh.)
6,132,000 x 0.059 = $361,788/yr.

Total Utility cost = $434,882/year or
$500,000/year (Sept. 1988 dollars)

Operating Labor Costs (June 1985 dollars)

Operator Labor (Assume 0.5 hrs/shift or 547.5 hrs/yr and a rate of $11.53 per hr.)

547.5 x 11.53 = $6,312/year.
$6,510/year (Sept. 1988 dollars)

Supervision (Assume 15 percent of Operator Labor.)

0.15 x 6312 = $947/year
$977/year (Sept. 1988 dollars)

Total Labor Cost = $7,487/year

Maintenance Cost

Labor (Assume 0.5 hrs/shift of 547.5 hrs/year and a rate of $11.53 per hour.)

547.5 x 11.53 = $6,312/year.
$6,510/year (Sept. 1988 dollars)

Material (Assume 100 percent of Maintenance Labor.)
$6,510/year (Sept. 1988 dollars)

Total Mantenance Cost = $13,020/year

Indirect Operating Costs

Overhead (80 percent of Operator, Supervisor and Maintenance Labor)
$11,200/year.

Property tax (1 percent of Total Capital Cost)
$114,100/year.

Insurance (1 percent of Total Capital Cost)
$114,100/year.

Administration (2 percent of Total Capital Cost)
$228,200/year.

Capital Recovery (16.3 percent of Total Capital Cost assuming equipment life of 10 years.)
$1,859,830/yr

Credit (Based on $0.2 per pound of methylene chloride)
$720,000/year.

Total Direct Operating Costs	$ 520,507/year
Total Indirect Operating Costs	$2,327,430/year
Credit	$ 720,000/year
Annual Cost	$2,128,000/year or
	$ 1,200/ton DCM recovered.

It should be noted that the annual cost does not reflect the cost incurred for replacement carbon.

A similar break down of cost can be prepared for a carbon adsorber for the emission stream from Building 20. Assuming a similar recovery efficiency, similar factors and costs, a carbon adsorber system would have the following costs:

Total Direct Operating Costs	$ 147,869/year
Total Indirect Operating Costs	$ 706,069/year
Credit	$ 147,420/year
Annual Cost	$ 706,518/year or
	$ 2,000/ton DCM recovered.

The cost for the Building 20 carbon adsorber also does not reflect the cost incurred for replacement carbon.

Thermal Incinerators

Alliance personnel contacted several manufacturers of thermal incinerator systems regarding the cost of a system for the emission streams in question. Alliance, however, was unable to contact an incinerator vendor who could provide the cost of equipment for this type of application. The best estimate that any vendor could make was that an incinerator for the Building 53 emission stream (500,000 cfm) would cost $7,000,000 and one for Building 20 (150,000 cfm) would cost $2,300,000.[4] The metal parts of each system would be fabricated with stainless steel. This cost does not include the cost of a caustic scrubber to deal with the HCl formation which may occur during the incineration process. During the conversations with the vendors, Alliance was told that it was unusual to be incinerating emissions streams containing DCM and with such high flowrates.[4,5] One of the major problems with this application is due to the low heat content of the emission stream, a supplemental fuel would be required to maintain the proper temperature for the destruction of DCM.

A break down of costs similar to those for the carbon adsorber can be prepared for each emission stream. For this application, Alliance assumed that the heat content of both emission streams is 1.0 BTU/ft^3. The cost of an incinerator for the Building 53 emission stream is as follows:

Purchase Cost for a 500,000 cfm flowrate incinerator.[4]
$7,000,000.

Total Capital expenditure (factoring in other direct costs and indirect costs)

$7,000,000 x 1.63 = $11,410,000.

Assume the destruction efficiency of the incinerator system is 99 percent (Combustion temperature of 2,200 °F and a residence time of 1 second). Thus, from emissions of 4,000,000 lbs/yr, 3,960,000 lbs/yr will be destroyed.

Utilities Required

Gas required (Assume the heat content of methane is 892 BTU/ft^3 and the heat recovered by the exchanger in the preheater system is 70 percent.)
Supplementary Heat required (Using Eq. 4.2-1 in the Handbook.[3])

$H_f = 8.433 \times 10^6$ BTU/min.

Gas Flowrate

$8.433 \times 10^6 / 892 = 9{,}454$ scfm.

Yearly Gas requirement = 4.969×10^9 ft^3/yr.

Fan electricity required (Assume a fan efficiency of 65 percent and a pressure drop of 7 in. H2O across the control system.)

2.0×10^{-4} x Flowrate x Press. Drop x Hrs =
Electricity required per year (kWh)

2.0×10^{-4} x 500,000 x 7 x 8760 = 6,132,000 kWh/year.

Utilities Cost (June 1985 dollars)

Gas cost (Based on $0.00425 per ft^3.)
4.969×10^9 x 0.00425 = $21,118,000/yr.

Electricity cost (Based on $0,059 per kWh.)
6,132,000 x 0.059 = $361,788/yr.

Total Utility cost = $21,479,788/year or
$22,151,000/year (Sept. 1988 dollars)

Operating Labor Costs (June 1985 dollars)

Operator Labor (Assume 0.5 hrs/shift or 547.5 hrs/yr and a rate of $11.53 per hr.)
547.5 x 11.53 = $6,312/year.
$6,510/year (Sept. 1988 dollars)

Supervision (Assume 15 percent of Operator Labor.)
0.15 x 6312 = $947/year
$977/year (Sept. 1988 dollars)

Total Labor Cost = $7,487/year

Maintenance Cost

Labor (Assume 0.5 hrs/shift of 547.5 hrs/year and a rate of $11.53 per hour.)
547.5 x 11.53 = $6,312/year.
$6,510/year (Sept. 1988 dollars)

Material (Assume 100 percent of Maintenance Labor.)
$6,510/year (Sept. 1988 dollars)

Total Maintenance Cost = $13,020/year

Indirect Operating Costs

Overhead (80 percent of Operator, Supervisor and Maintenance Labor)
$11,200/year.

Property tax (1 percent of Total Capital Cost)
$114,100/year.

Insurance (1 percent of Total Capital Cost)
$114,100/year.

Administration (2 percent of Total Capital Cost)
$228,200/year.

Capital Recovery (16.3 percent of Total Capital Cost assuming equipment life of 10 years.)
$1,859,830/yr

Total Direct Operating Costs	$22,171,507/year
Total Indirect Operating Costs	$ 2,327,430/year

Annual Cost	$24,499,000/year or
	$ 12,400/ton DCM destroyed.

As noted above, the annual cost presented does not included the cost of a caustic scrubber to remove HCl formed during the incineration process. Thus, this annual cost estimate should be considered low.

A similar break down of cost can be prepared for a incinerator for the emission stream from Building 20. Assuming a similar destruction efficiency and heat recovery by the preheater system, and similar factors and costs, a incinerator system would have the following costs:

Total Direct Operating Costs	$6,656,507/year
Total Indirect Operating Costs	$ 772,247/year

Annual Cost	$7,428,754/year or
	$ 18,300/ton DCM destroyed.

This estimate also does not include the cost of a caustic scrubber. It should be noted that because of the low heat content of the emission stream, the majority of the cost for the thermal incinerator is the purchase of supplemental fuel to maintain the proper combustion temperature.

CONCLUSION

For the applications presented above, thermal incineration has been shown to be the least cost effective means of the two systems examined for removing DCM from an emission stream. This is due the large amounts of supplemental fuel required to maintain the combustion chamber at the proper temperature.

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4. Personal Communication between Stephen Walata, Alliance Technologies Corporation, and Ray Elsman, Huntington Energy Systems Inc., Union, NJ. December 19, 1988.

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APPENDIX D

Comparison of Technology Assessment with Kodak's BACT Report

ALLIANCE
Technologies Corporation

December 21, 1988

TO: Fred Dimmick, EPA/OAQPS
Charles Darvin, EPA/AEERL

FROM: Richard Rehm RMR
Stephen Walata SAW

SUBJECT: Comparison of Technology Assessment with Kodak's BACT Report

This memo is to fulfill Task 3 of Work Assignment 13 of Contract No. 68-02-4396. Alliance personnel reviewed Kodak's Best Available Control Technology Analysis for Dichloromethane Air Emission Sources at Kodak Park which will be referred to as the Kodak report. The following is a comparison between this report and Alliance's Source Characterization and Control Technology Assessment of Methylene Chloride Emissions from Eastman Kodak Company, Rochester, NY (to be referred to as the Alliance report) which was generated for Task 2 of this work assignment. Each report's goal was to provide an assessment of control technologies to reduce dichloromethane (methylene chloride or DCM) emissions from the Kodak Park facility in Rochester, NY.

Both reports provided background information of the uses of DCM at Kodak Park. The Kodak report provided a more detailed review of the processes which use DCM including schematic diagrams of the processes. The Alliance report chose to exclude a discussion of the processes to avoid the possibility of revealing confidential information.

Both reports discussed the methods of emission estimates. Once again, the Kodak report provided a more detailed review of the techniques used for each estimation method. The Kodak report, however, did not address the possibility that several emission estimates may be erroneous. Alliance discovered this problem during the plant visit when Kodak personnel indicated that the emission estimates of emission points 52-37 (Batch Mixers) and 21-12 (Kady Mill Exhaust) were overestimations. For its part, Kodak assesses the accuracy of the emission estimates by stating that on a mass basis, estimates for over 78 percent of the total amount of DCM emitted annually were made using monitoring data. Still, there is no mention in the Kodak report of the possibility of improving overall emission estimates.

Included in both reports are detailed descriptions of the category 1 and 2 emission sources at Kodak Park. The Kodak report included the projected emissions which will result from the installation of the proposed acetate film base casting machine. These emission estimates include the contained emissions from the ventilation system of the new room which will house the new machine and the emissions associated with the planned 18,000 cfm carbon adsorber used for process air draw-off. The Alliance report included neither of these estimates. During the plant visit by Alliance personnel, Kodak

500 Eastowne Drive, Chapel Hill, North Carolina 27514 919-489-6550
A TRC Company

personnel indicated that the design plans for the new casting machine and new carbon adsorber were not finalized. Thus, the projected emissions for the new casting machine could not be accounted for with any degree of certainty. The emissions projected for the new carbon adsorber had yet to be developed at the time of the plant visit. What was included in the Alliance report were the emissions from the 4,000 cfm carbon adsorber currently being used for process air draw-off.

Both reports included process changes which are being planned by Kodak to reduce DCM emissions. Kodak calls these process changes their Emission Reduction Program. The process changes regarding the improvement of the existing machine's seal integrity (called the Machine Integrity Program by Kodak) are similar in both reports. This is because the Alliance report contains a verbatim account of the changes discussed during the plant visit. Kodak also proposed to reduce slightly the positive pressure occurring in the casting hopper of some machines. This will be possible because of the improvement in the seal quality. The Alliance report misstated that the anticipated completion date of the Emission Reduction Program was 1992 instead of 1990 as reported by Kodak.

The Kodak report contains several sections which were not included in the Alliance report. The subjects covered by these sections are:

A) The decision criteria used by Kodak in the determination of the best available control technology (BACT). Kodak defined what was felt to constitute BACT through the cost effectiveness of the proposed control. The cost effectiveness level which Kodak believes is reasonable for a control technology is a cost of $2,000 to 3,000/ton of pollutant removed.

B) The methodology used by Kodak to evaluate BACT for an individual emission source. This included consideration used to evaluate possible combining of emission sources.

C) A statement of Kodak's manufacturing concerns regarding the acetate film base. Included were general and worker safety, equipment corrosion and product quality considerations.

The Alliance report excluded the discussion of these subjects since the approach of the report was to provide potential control technologies which were reasonable for Kodak to apply to the individual emission sources.

Kodak is planning to install a total hydrocarbon measurement system in Building 20. The Alliance report concurs with this action if the proposed measurement system will operate on a continuous basis. The Kodak report did not indicate whether this would be the case.

Each report provided a discussion on control alternatives. The Alliance report did not address the possibilities of process changes or material substitution as in the Kodak report. Alliance personnel felt that the lack of expertise in these areas would hamper efforts to suggest viable alternatives and thus concentrated on add-on control devices. The Alliance report discussed add-on control devices on a general level (i.e. oxidation and recovery type devices). The Kodak report's discussion of add-on control devices covered each individual type (i.e. condensers, absorbers, etc.). The Kodak report also discussed several types of carbon adsorbers such as granular beds, carbon fiber, combination systems and portable granular beds. The Kodak report, for the most part, defended the assessment of the add-on control devices by providing physical data either in the text or Appendix B. There is, however, one exception to the supporting of assessments and this dealt with absorption systems. Kodak provided vapor-liquid equilibrium data to support the claim that water is a poor material to use in a scrubber. Yet when Kodak discusses the use of alcohol in a multiple stage absorber, there are no data provided to support Kodak's claim that such a system is a feasible means of reducing DCM emissions. The Kodak report concludes that at the present time, there is no viable solvent which can be substituted for DCM.

The Kodak report discusses the new casting machine, its projected emissions and the application of a BACT analysis for it. The majority of the discussion was concerned with changes made to the new machine's design, as opposed to the existing casting machines, to provide what Kodak believes is the best machine design. The discussion also included an evaluation of placing an add-on control device (carbon adsorber and thermal incinerator) on the new machine room exhaust and the exhaust from the machine air draw-off source (the proposed 18,000 cfm carbon adsorber was assumed to be the base case.) Kodak concluded that neither device would be a cost effective means of reducing DCM emissions. Thus, the design of the new machine was chosen as BACT for the new machine room exhaust and the base case was BACT for the machine air draw-off source. The Alliance report did not address these issues regarding the new casting machine.

Concerning the control alternatives evaluated for the existing emission sources, Kodak has selected the base case as BACT for all except the following emission points. For the existing machine room exhaust (emission points 53-85, 53-38 and 20-68), Kodak has selected as BACT the Machine Integrity Program. A carbon adsorber was the control device selected as BACT for reducing the emissions from the batch mixers (emission point 52-32). Kodak also plans to reroute the vent flows from the hopper cleaning baths into the proposed replacement carbon adsorber (18,000 cfm) and reroute the remaining floor sweeps to be discharged with emission point 53-92. Kodak selected as BACT for the storage vessel vent (emission point 53-96) and the floor sweeps (emission point 53-32/53-92) the replacement of level sensors; however, there is no description in the Kodak report regarding this control alternative.

The Alliance report agrees with Kodak that the Machine Integrity Program is a reasonable control alternative for reducing the DCM emissions from the

existing machine room exhaust. The reports are in agreement about controlling the batch mixer emissions with a carbon adsorber, however, the Alliance report recommends Kodak consider the inclusion of the emissions from the felt wash process (emission point 54-29) to this control device. Alliance concurs with Kodak's plan to reroute the vent flows from the hopper cleaning bath to be included with the flows to the proposed replacement carbon adsorber.

The Alliance report disagrees with Kodak's assessment of control alternatives for several emission points. The first emission point of contention involves the storage vessel vents (emission point 53-96). Kodak argues that even though the concentration of DCM may be high when the tanks are being filled, the average concentration will be low due to infrequent use of the system. Thus, a control device would not be a cost effective alternative for reducing DCM emissions from this point. Kodak bases this assessment on the premise that the control device would be dedicated to the emission source. Alliance believes that including the vent flows from this emission source with the flows to the proposed 18,000 cfm carbon adsorber would be a reasonable control alternative. This source emits a greater amount of DCM per year than the hopper cleaning bath vent flows. The average concentration of DCM in the emission stream was calculated by Alliance (based on a flowrate of 1 cfm) to be 200,886 ppm. The variability of the flowrate from this source would be negligible when compared to the total flowrate to the carbon adsorber. The characteristics of this emission stream meet Kodak's criteria for combining sources.

Another point of disagreement between the reports concerns the condenser controlling the emissions from the Building 54 vent system (point 54-15). Kodak contends that the only cooling fluid available for the condenser is $9^{o}F$ brine, consequently the condenser is only 50 percent efficient. Alliance considers a properly operated condenser should have a removal efficiency of 95 percent for the DCM concentration present in this stream. If changes in the operating parameters to achieve this removal efficiency cannot be made, then Kodak should give serious consideration to replacing the current condenser with a more efficient model.

The next point of disagreement between the two reports involves the scrubbers (points 120-7 and 142-1) being used at the Kodak Park facility. Kodak selected as BACT the base case. An EPA document cited by Alliance suggests that a scrubber system works best when the influent concentration is no greater than 10,000 ppm.[1] Currently the effluent concentrations from the scrubbers are in excess of 10,000 ppm. Subsequently, Alliance recommended that a dilution stream be applied to the influent stream of each scrubber.

The Kodak report provided a BACT analysis and potential emission reduction plan for category 3 emission sources. This group of emission sources was beyond the scope of the work assignment and were not included in the Alliance report.

Both reports discussed the possibility of reducing fugitive (non-point source according to Kodak) emissions at Kodak Park. Current efforts presently employed at Kodak Park, for the most part, rely on visual inspections to detect

leaks which are the source of fugitive emissions. The Kodak report presented a three step program which Kodak considers as BACT for these emission sources. The first step is to improve estimates and characterizations of fugitive emission sources. The next step would be to take advantage of reduction opportunities when warranted by cost, time, and reduction potential. The last step would be to monitor reduction activities to quantify the progress being made. The Kodak report does not make a projection as to the reduction in DCM emissions as a result of this program. The Alliance report recommended the implementation of a leak detection and repair (LDAR) program using EPA Reference Method 21. EPA documents indicate that the institution of a LDAR program can reduce fugitive emissions by 60 percent.[2]

The Kodak report provided a detailde break down of costs for a carbon adsorption system and a thermal incineration system in Appendix E. These systems were designed to control the total emissions from the machine room exhaust in Building 53 (points 53-85 and 53-38). Additionally, Kodak provided annual cost estimates for control systems (carbon adsorber and thermal incinerator) for each individual emission source as part of their review of different control alternatives in Appendix G. Alliance provided an addendum to the original report in which the annual costs were estimated for the same two control systems. Alliance combined all the uncontrolled emission streams in Building 53 into one source to be processed by a control system. Cost estimates for the control systems were developed for this source and the machine room exhaust in Building 20.

The annual cost estimates developed by each report differ greatly, with the Kodak report supplying the greater estimates. This difference is due to the assumptions and decisions made by each report. The Kodak proposed systems have in-line back-up capabilities which add to the overall cost of the system. The Alliance systems are based on the equipment necessary to perform the task, thereby minimizing the purchase cost of the system. In addition, the materials-of-construction can add significantly to the cost of the system. During the conversations with carbon adsorber system vendors, Alliance was told that the use of titanium in constructing a system, as proposed by Kodak, would effectively double the cost of that system.[3] The material currently used in carbon adsorber systems recovering DCM is 904 stainless steel. The Kodak report does not fully explain the rationale behind having an adsorption cycle for each tank of approximately 90 hrs. In carbon adsorber design equations, the amount of carbon the system requires is proportional to the length of the adsorption cycle.[1] The longer the cycle, the more carbon would be needed in the system. By choosing a shorter adsorption cycle, Kodak could reduce the amount of carbon required by the system and therefore reduce overall costs. Each report uses different costs for labor and utilities. The differences in these values will contribute to the differences in the annual costs. The Kodak report did not provide the assumptions or equations used to estimate the required labor and utilities for each control system. Consequently, Alliance was unable to determine the validity of these cost estimates. There are factors which contribute to the lower annual cost estimates presented by the Alliance report. The annual cost incurred for the replacement carbon in the

adsorber system nor the cost of a caustic scrubber to remove HCl produced during thermal incineration were included in the final estimate. The latter was due to Alliance's inability to contact a vendor of thermal incinerator systems who was experience in the incineration of DCM. There is, however, one point that both reports agree. That is for the applications presented in either report, thermal incineration is the least cost effective means of controlling a DCM emission source.

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(*) NTIS No. PB81-152167.